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NUCLEAR RAW MATERIALS PROSPECTION MISSION 1965

Report to the Government of the Republic Oriental Del Uruguay

J. CAMERON

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REPORT TO THE GOVERNMENT OF THE
REPUBLIC ORIENTAL DEL URUGUAY

NUCLEAR RAW MATERIALS PROSPECTION MISSION 1965

by

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RESULTS

A preliminary reconnaissance survey of Uruguay for nuclear raw materials has been completed. Over 7,700 kilometers have been surveyed by carborne scintillometer and 112 radioactive anomalies have been discovered.

Favourable areas with high incidence of anomalies and indications of uranium occurrences have been de-limited in the Minas-Aigua, Valentines-Treinta y Tres, Las Cañas, Minas de Corrales and Melo areas. A possibly important indication of uranium at Paso de Las Piedras, Department of Durazno, has also been discovered by other means.

The area investigated only comprises 0.83% of the total area of Uruguay and the high incidence of anomalies discovered and the other indications of uranium within this area are favourable and encouraging factors for further work.

RECOMMENDATIONS

1. An immediate continuation programme for the first half of 1966 has been outlined and involves the checking of anomalies found in 1965 and the preliminary assessment of uranium occurrences. The cost of this work would be at the same rate as has been incurred in late 1965.

2. A technical case has been made out for a long-term programme for prospection and development of nuclear raw materials, but the policy on whether it should be started at this time, its extent, future national value and how it should be financed, administered and executed should be first considered.

Uranium is at present in over-supply in the western world and there appears to be little opportunity for sales from new sources up to the early or mid-1970's. From the early 1970 's onwards the prospection, development and production of uranium will probably be accelerated to keep pace with increasing demand for nuclear power fuel. The initiation of a long-term prospecting programme in 1966 may, therefore, be very correct timing to take advantage of this projected increased demand if economic reserves are also proved.

A long-term national programme would be planned in succeeding phases of evaluation work and no major expenditure would be made on a new phase until at least minimum success had been proved in the

preceeding phases. If minimum success were proved on all phases then such a programme would be likely to last at least five years, involve a minimum operating expense of about US$ 600,000 and a capital expenditure of US$ 250,000 and require a senior staff of up to 45 persons. If uranium were found, it would only be of interest if it could be produced at a price below or comparable with existing or forecast world prices. "Minimum success" for a programme on this scale means the discovery of approximately 500 tons U_3O_8 recoverable at under US$ 8.00 per pound and this is not a large tonnage in terms of discoveries in other countries.

If a long-term programme were decided upon, then it would be preferable that a new organization should be set up to deal with it. Ideally, this should be a raw materials department of a reorganized and executive National Atomic Energy Commission, responsible only to a high Government level and drawing its own funds to finance all operational projects.

A recommended technical programme has been worked out to cover the period 1966 to 1970. The most important early requirement is an aerial scintillometer survey of favourable areas. A first season programme of 28,000 square kilometers has been recommended. Follow-up ground survey phases and drilling and mining programmes are also suggested.

TECHNICAL ASSISTANCE

The most immediate requirement is for aerial scintillometer survey equipment. This equipment should be hired and not purchased.

The expert suggests that the International Atomic Energy Agency might be approached to provide the equipment and an expert to train personnel.

Another convenient and practical possibility would be with the assistance of the Argentine CNEA whom the expert understands would be willing to cooperate in this matter. The possibility could be explored through the intermediary of the IAEA, or directly between Governments.

It is also recommended that the Uruguayan counterpart officers visit the Argentine Raw Materials Directorate of the CNEA to study organization and all technical aspects.

If a long-term programme is resolved upon, then the assistance of an expert to advise and help direct the programme over the years 1967 to 1969 should be requested from IAEA.

FELLOWSHIPS

There is a considerable requirement for higher education in the mineral procurement and assessment field in Uruguay. Application to the Agency for fellowships for the present counterpart officers to cover advanced mineral procurement should be made. Other fellowships covering more specific fields such as prospection, drilling and mining operations should also be considered.

MONAZITE BEARING HEAVY MINERAL COASTAL SANDS

Prospection work by the Division of Scientific Investigations of ANCAP since 1950 has proved a reserve of three million tons of heavy minerals at Aguas Dulces and indicated the probability of a further 20 million tons at other areas along the Eastern coasts. Present values are of the order of US$ 25.00 per ton of heavies.

Laboratory work has shown that there is no technical problem involved in the recovery and high-grade concentration of the constituent minerals, ilmenite, rutile, zircon and monazite. The calculated monazite reserve may have a content of thorium and uranium of the order of 6,000 ton ThO_2 and 350 ton U_3O_8.

No production from the heavy mineral sands has yet been attempted.

Preliminary studies by ANCAP foresee considerable economic difficulties in marketing, due mainly to the transport costs of the final products.

The writer recommends that ANCAP request the assistance of an experienced heavy minerals consultant engineer from the United Nations to study the whole problem and advise especially on production costs and marketing possibilities and to initiate pilot plant production on an industrial scale.

INTRODUCTION

Terms of Reference of the Assignment

The Government of the Republic Oriental del Uruguay made a request to the International Atomic Energy Agency in 1964 for the assistance of an expert in prospection for nuclear raw materials. The duties of the one year assignment were described in the following terms:

1. To advise on the development of a programme of prospection for uranium and other nuclear raw materials.
2. To participate in field operations of nuclear raw materials prospection and train national staff.

The above request originated from the Geochemical Section of the Faculty of Chemistry of the University of Uruguay in January 1964 in association with the Administración Nacional de Combustibles Alcohol y Portland (ANCAP) and the Institute of Geology and was sponsored by the Comisión National de Energía Atómica (CNEA).

The stated intention was to develop a prospecting programme by using mobile carborne scintillometer methods and geochemical techniques.

Previous nuclear raw material prospecting work in Uruguay had been limited to the investigation of one small radioactive anomaly in the batholith of Sauce de Pan de Azúcar and carborne prospecting with a hand held scintillometer in the Department of Treinta y Tres. More extensive and detailed work had, however, already been done by ANCAP on the monazite bearing coastal beach sands.

The expert arrived in Montevideo on 15th January 1965 in order to fulfill the above request.

Preliminary discussions with a representative committee sponsored by the CNEA and drawn from the above organizations revealed complete agreement that the 1965 programme should be regarded as a low cost preliminary reconnaissance, designed to assess the radioactive minerals possibilities in a country where little previous work had been done but where the geological conditions are generally favourable.

It was agreed that the carborne scintillometer would be the most suitable tool for this purpose and the programme was redefined as follows:

1. Preliminary geological reconnaissance surveys.
2. Carborne scintillometer surveys.
   a. General survey to define areas of higher favourability
   b. Systematic surveys of more favourable areas

3. Follow-up evaluation work on any major anomalies found.

4. Assessment or advisory work on the heavy mineral beach sands.

Items 2 and 3 included the training of Uruguayan staff.

In addition to this request for technical assistance to IAEA, the CNEA, on its own initiative in mid-1964 entered into negotiation with the Commissariat à l'Energie Atomique de France (CEA) for technical cooperation in nuclear sciences. In late September 1965 a group of three French scientists from CEA under M.A. Grimbert arrived in Uruguay to carry out a programme of geochemical prospection for uranium.

Geographical Note on Uruguay

The Republic Oriental del Uruguay is located between 30° and 35° latitude South and 53° and 59° longitude West. Its shape is that of a triangle opening out to the sea, bordered by Brazil to the North, Argentina to the West and the Atlantic Ocean and the River Plate to the East and South. It covers an area of 187,225 square kilometers or 72,172 square miles. The terrain is gently undulating with the altitude mainly between sea level and 200 meters. The maximum altitude of 501 meters is reached in the Sierra de las Animas about 70 kilometers East of Montevideo. Uruguay is crossed by many rivers, the chief of which is the Rio Negro in the center of the country. On this river there is a dam for the major hydroelectric project of the country, which forms a large artificial lake known as Rincón del Bonete between the Departments of Tacuarembó and Durazno. The country is divided into nineteen Departments each with its own capital.

Over 80% of the country is covered by range grassland. Arable land amounts to about 10% and natural and planted forest to about 2.5% of the total area of the country. The extensive very deep soil areas found in the Argentine are not common in Uruguay where rock outcrops are relatively frequent, All these features make Uruguay extremely well adapted for geological and geophysical exploration whether by aerial or ground methods.

A series of principal highways radiate from Montevideo some of which are asphalted. Secondary roads give communication between the district capitals and small towns and are mainly all-weather roads.

Extensive un-surfaced "campo" roads exist between villages and through estancias. Some of these may not be negotiable in bad weather, and a four wheel drive vehicle is a necessity. Even so, the kilometer-area ratio for all Uruguayan roads is higher than in any other country in Latin America. The country is therefore very suitable for the use of a carborne scintillometer as a prospecting tool.

Unfortunately the basic topographic map and aerial photograph situation is not very satisfactory. There is a topographic map on the scale of 1:500,000 and Department maps on the scale of 1:100,000 exist but are of varying standard. Topographic map coverage on the scale of 1:50,000 exists for the coastal regions and some special areas of the interior only. Aerial photographic coverage is also very limited but work is now proceeding on this and some important areas have been photographed during 1965.

General Situation

During 1965, Uruguay has suffered severe financial and economic difficulties which have had some adverse effect on the project. The financial problems of the Government have been reflected in the difficulties encountered in obtaining resources to run the prospecting programme. Strikes of Government and Municipal workers have been frequent and have included the personnel of the University and the Ministries connected with the project. The Uruguayan peso has suffered considerable devaluation during the year and import restrictions have been placed on a wide variety of imported materials.

Summary of the Geology of Uruguay

The geology of Uruguay can roughly be sub-divided into five principal types covering six fairly well marked areas. These are indicated on Figure 2 (a).

1. The southern and eastern two-thirds of the country consist of Pre-Cambrian crystalline basement schists and gneisses, granites and the "Serie de Minas" composed of a variety of metamorphic rocks.

2. In the north-east corner of Uruguay, in a triangle approximately defined by the towns of Rivera and Melo to the north and with an apex somewhat to the south of the artificial lake of Rincón del Bonete there is an extensive area of sediments, ranging in age from Devonian to Upper Triassic and including all the Gondwana sediments of the country. These sediments range from conglomerates, course and fine sandstones, siltstones and some limestones. A window of Pre-Cambrian crystalline basement rocks exists in the middle of these rocks near the town of Minas de Corrales.

3. In the west of the country, bounded by the river Uruguay and extending from Salto in the north to near Nueva Palmira in the south there is an area of Cretaceous and Tertiary sediments, mainly sandstones and siltstones with some limestones.

4. All of the north-west of the country, extending as far south as the town of Durazno is covered by Neo-Gondwana volcanic rocks, mainly basalts. A smaller area of these rocks is also found overlying the Pre-Cambrian rocks near Minas.

5. Two extensive areas of Pleistocene and Recent sediments occur in the south, the first along the eastern border with Brazil in the low lying ground near the Laguna Merin and the second to the north of Montevideo, in the so-called "graben" of Santa Lucía.

Major structural features are not prominent. The "graben" of Santa Lucía is reputed to be bounded by two E.N.E. trending fault systems, one immediately north of Montevideo and the other trending from the coastal town of Colonia through the town of San José de Mayo. These structures appear to abut on the north-south trending zone of the "Serie de Minas" and may reappear north-west of Minas bounding Gondwana age volcanics.

Metalliferous occurrences in Uruguay are relatively few. Small occurrences of copper, lead and zinc are located in the "Serie de Minas" mainly to the south of the town of Minas. Some of these were worked on a small scale in the 1920s and 1930s. Small gold occurrences are also reputed to exist in this area. An old gold mine, no longer in operation exists in the north of the country near the town of Minas de Corrales. Extensive, but as yet unexploited, low grade iron ore deposits exist near the village of Valentines on the boundary between the Departments of Florida and Treinta y Tres. Other iron ore deposits exist in the Departments of Rivera, Durazno and Lavalleja. These locations are indicated on Figure 2 (b).

Extensive heavy mineral beach sand deposits of ilmenite, rutile zircon and monazite are known all along the eastern coast line from Atlántida to the Brazilian border. Some occurrences to the west of Montevideo have also been reported.

Favourable Areas for Uranium Mineralization

The geology of Uruguay when compared to the geological environments of uranium occurrences in other parts of the world could be considered as reasonably favourable for the discovery of uranium minerals.

The crystalline basement areas, particularly in the regions of granitic intrusives and near metalliferous occurrences would always be considered as generally favourable and these conditions are fulfilled in the Minas, Valentines and Mines de Corrales areas.

Of the sedimentary areas the Devonian-Gondwana area of the north-east would appear to be the most favourable. Besides their

general host rock favourability, their relatively close association with the metalliferous areas in the Pre-Cambrian rocks, i.e. the Valentines and Minas de Corrales areas, is a favourable factor.

With apparently less favourability, but still of interest there is the extensive Cretaceous-Tertiary sedimentary area of the west of the country.

The two Pleistocene-Recent areas of Laguna Merin and Santa Lucía are probably of little interest. The volcanic area of the north and west can probably be ruled out as of no interest.

After the initial study of the geology of Uruguay the writer therefore summarized the order of favourability for uranium mineralisation as follows:

Favourable

1. Pre-Cambrian basement areas near granites, other metalliferous occurrences and major structural features.
2. Other Pre-Cambrian areas.
3. Devonian and Gondwana sedimentary areas.

Possible

4. Cretaceous and Tertiary sedimentary areas.

Unfavourable

5. Pleistocene and Recent Sedimentary areas.
6. Neo-Gondwana volcanic areas.

Previous Nuclear Raw Materials Prospecting

A radioactive anomaly was discovered in May 1949 within the batholith of Sauce de Pan de Azúcar in the Department of Maldonado. The anomaly was investigated by ANCAP staff of the Division of Scientific Investigations, Pando Laboratories, under the direction of Ing. Walter S. Hill in 1955 and 1956. A small grid map was made of the area, a trench was dug and seven shallow drill holes were put in. Laboratory investigations were done and zircon and uranothorite were identified as the source of the radioactivity. The occurrence is small and no further work was done.

In 1958 and 1961 ANCAP carried out a prospecting programme in the Department of Treinta y Tres. A hand-held scintillometer was carried in a jeep over the available roads in the area west of the town of Treinta y Tres as far as the Department boundary near Valentines. Some 16 radioactive anomalies were found and located on a map. No follow-up work was done.

WORK ACCOMPLISHED DURING 1965 PROGRAMME

The primary requirement in 1965 was a low cost preliminary reconnaissance survey on a national scale, and the programme outlined above under "Terms of Reference" was therefore planned and initiated.

Instrument Requirement and Availability

The total funds made available to the Uruguayan Government by IAEA for instruments for the 1965 Programme amounted to US$ 5,000.

No instruments had been ordered through IAEA at the time of the expert's arrival in Uruguay.

The principal requirement was the set of carborne scintillometer equipment but at least three Geiger counters or portable scintillometers for follow-up field work were also necessary.

The expert was aware that the purchase of the carborne equipment within the budgeted amount and with rapid delivery would be extremely difficult to fulfill and therefore suggested that the most practical method of getting the programme going at the earliest possible stage would be to hire equipment. This was agreed to by the Uruguayan authorities and by IAEA and a set of equipment consisting of:

One scintillometer detector unit Type 1444 A
One ratemeter Type 1444 A
One recorder Type 1487 A with alarm unit

and all necessary accessory equipment and rolls of recorder paper was hired from the Atomic Energy Division of the British Geological Survey through the Agency at a cost of US$ 50.00 per month. This did not however prejudice the eventual delivery of carborne equipment on a permanent basis to the Uruguayan Government from IAEA when such became available.

The hired equipment was air freighted from London in early April but was not released from the customs until 10th May. Difficulties in obtaining a suitable vehicle were encountered but finally an Austin Gypsy four-wheel drive vehicle was provided by ANCAP. The preparation and fitting out of the vehicle took a further few weeks and it was not until the 14th of June that the equipment and vehicle were operational.

The first part of the equipment provided by the Agency to the Uruguayan Government on a permanent basis, consisting of three Gammameters GMT3 and one borehole probe MB 3G 12 suitable for use with the GMT 3T instruments arrived in early September.

The carborne scintillometer equipment to be provided on a permanent basis was ordered in mid-year from Baird-Atomic Inc., Cambridge, Massachusetts, U.S.A., but had not arrived in Uruguay before the end of the expert's assignment.

During the earlier part of the year no suitable portable Geiger counter or scintillometer equipment was available although old unserviceable models existed both in the Faculty of Chemistry and ANCAP.

Beta-scaler equipment suitable for radiometric analyses of powder samples exists at both the Pando Laboratories of ANCAP and in the Faculty of Chemistry although no standard samples of uranium ores are available for comparison.

With the arrival of the CEA team from France in later September the instrument position for the general programme was greatly improved as they brought six S.R.A.T. portable scintillometers and three Gammameters, as well as complete geochemical prospecting equipment.

Carborne Scintillometer Survey.

Summary

The work accomplished and the results obtained from June to December 1965 may be summarized as follows:

Number of Working Days	Total Kilometers Surveyed	Number of Radioactive Anomalies Discovered	Number of Anomalies Re-checked	Number of Anomalies Recommended for further work
72	7,720	112	54	22

Owing to lost time due to repairs to both the equipment and the vehicle, to staffing difficulties and general administrative problems such as the initial delay in getting the equipment operational, the number of working days and the kilometers surveyed are only about one third of the amount which the expert estimated should have been possible from the time the equipment arrived in the country in early April. Nevertheless, in regard to the number of anomalies discovered, the programme must be considered as a success.

Working Technique

The equipment consists of a detector unit, a ratemeter unit and an automatic recorder unit. The detector unit was mounted on a tripod above a platform firmly fixed to the roof of the vehicle and thus about three meters above the ground. The ratemeter and the automatic recording unit were fixed in positions within the cabine of the vehicle.

In normal operation only two persons are required; a driver and an operator, who, besides working the instruments and recording the survey data, should have some knowledge of geology and the mode of radioactive occurrences.

The operator records all working facts on a daily operational log sheet. He also records the route followed on a map or aerial photograph.

When set on ratemeter range "2", background radioactivity on clean silica sand or volcanic areas normally gives a reading of 10. This somewhat arbitrary figure has been used as "normal background" and a radioactive anomaly has been defined as a reading of 25 or over, that is, two and a half times normal background.

In operation, such anomalies are automatically recorded on the recorder paper and the exact geographic location of an anomaly is recorded on the log sheet and the map or photograph by the operator.

Further records kept are the weekly report sheet, the map sheet record of anomalies and the individual anomaly record.

As no complete coverage of Uruguay by 1:50,000 topographic maps nor by aerial photographs exists, the base map which was used for the survey was the 1:500,000 Carta Geográfia of the Servicio Geográfico Militar, photographically enlarged to the 1:100,000 scale and divided into thirty-two separate sheets.

These 1:100,000 sheets were numbered and named (Figure No.1 and Appendix No.1) and formed the base map of the survey.

Despite the fact that in some parts of the country much more satisfactory aerial photographs and 1:50,000 topographic maps can be used for the actual field work the naming and numbering of anomalies has been related to the 1:100,000 map sheets as being the only system giving complete coverage.

Anomalies discovered within a 1:100,000 sheet have been numbered consecutively in order of discovery and referred to as, for example, "Anomaly 7 (26)" being the seventh anomaly discovered in the Aigua sheet No. 26. A brief location description should also be added thus:

"Anomaly 7 (26)near kilometer post 159 on Route 8, Minas to Treinta y Tres".

Parallel with these records the 1:500,000 topographic and geological maps with the anomalies discovered located on them have been maintained in the headquarters office. The essential facts of these two maps are indicated on Figures 1 and 2.

At the end of the expert's assignment all these records were up to date and it is strongly recommended that the system be maintained as a basis for all future work on nuclear raw materials in Uruguay.

Anomalies Discovered

1. Preliminary General Reconnaissance Survey

A reconnaissance survey was first made over all the principal geological and geographic areas of the country, to obtain first evidence on potential favourability.

The survey covered 2,720 kilometers and 18 radioactive anomalies were discovered. Of these, 13 were in Pre-Cambrian rocks (seven in crystalline schists and gneisses and six in granites or granitic gneiss), two were in Gondwana sediments (the San Gregorio basal formation near Melo) and the other three were due to monazite beach sand areas on the coast.

No anomalies were found in the Cretacious-Tertiary formation although in a few locations the radioactivity recorded approached the anomaly limit. No anomalies were recorded in the 643 kilometers covered in the Neo-Gondwana rocks of the north.

Geographically all the anomalies except one were found in the eastern half of the country, principally in the Minas-Aiguá area.

The results of the preliminary reconnaissance survey was successful in indicating a considerable number of previously unknown anomalies thus giving encouragement for more systematic work. The results were also in accordance with the predicted favourability pattern.

During the remainder of the working period both general and systematic work was done in favourable areas. The anomaly lists are given in Appendix No. 1 and the routes covered and the locations of anomalies are shown on Figures No. 1 and 2.

The principal areas of anomalies may be briefly described as follows:

2. Piriápolis - Minas - Aiguá - Velázquez - Rocha Area

This extensive area in the south-east of the country contained in parts of Sheets 25, 26, 30 and 31 is in Pre-Cambrian rocks including crystalline schists and gneisses, granites and the metamorphosed rocks of the "Serie de Minas". Some more recent volcanic rocks lie immediately north of the near Aiguá. The area includes some of the more highly faulty and structurally important sections of the country and also includes the small copper, lead and zinc occurrences in hydrothermal veins, and a few iron ore occurrences. The previously known anomaly in the batholith of Sauce de Pan de Azúcar is within the area.

Forty anomalies out of the total of 115 have been located in the area.

Of this total 28 have been checked on the ground and eight of these have been recommended for further work.

Many of the anomalies inspected and dismissed as of no further interest, originate from abnormally radioactive zones in granite or granitic gneiss and show no features which could be potential host structures.

This is the type of occurrence found in the batholith of Sauce de Pan de Azúcar in 1949. It is possible that these are due to segregation of weakly radioactive accessory minerals (possibly thorium minerals) in these rocks. Further mineralogical studies should be done on this problem.

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Some of the more interesting anomalies are as follows:

Anomaly 1 (25) km 134 on Route 8 North of Minas

The carborne scintillometer recorded only a three times background anomaly but on ground checking the radioactivity was found to originate from a poorly defined, hematitic-jasper alteration zone striking N45°E in granitic gneiss. A maximum Gammameter value of 120 was registered on the structure. Indications of fresh pyrite in the altered zone is a favourable feature. No secondary uranium minerals were seen. A map of the occurrence is shown as Figure No. 5.

Although of little apparent importance in itself, it was the first indication of a classic type of uranium occurrence, the hematitic-jasper type hydrothermal vein structure, and there is the possibility that other such veins may exist in this structurally favourable area.

Anomaly 12 (3). Three kms. West of Route 12 and 10 kms south of its Junction with Route 60

The carborne scintillometer gave a reading of 30 and it was found that the cause was due to loose quartz boulders giving readings of up to 160 on the Gammameter. These boulders probably originate from some nearby vein structure. Traversing and grid mapping should be done to locate the host structure. The possibility that the radioactivity is due to a thorium mineral should be examined.

Anomaly 25 (26). Km 33 to km 46 on Route 15. Rocha to Velázquez

One of the most extensive continuous anomalies found was a 13 kilometer section of Route 15 immediately north of Rocha. The carborne scintillometer recorded continuous values of between 25 and 45 over the whole section. While the cause may be a high density of radio-

active accessory minerals, possibly thorium bearing, in the granitic rock the area should nevertheless be checked in detail.

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The high density of radioactive anomalies in this whole area calls for a considerable amount of further work, both mineralogical and field prospecting.

The French CEA group have completed a geochemical survey of an area between Pan de Azúcar and Minas as part of their programme.

3. Valentines - Treinta y Tres Area

Part of the area covered by the ANCAP prospecting team in 1960 in the Department of Treinta y Tres was checked by the carborne scintillometer and the expert extended the work to include the Valentines iron ore area which has been mapped and studied extensively by Q.I. Jorge Bossi.

Thirty-four anomalies were located in a comparatively small area in sheet 20 and 21 at the junction zone of three Departments: Treinta y Tres, Durazno and Florida. These included only three of the anomalies originally found in the ANCAP prospection of 1958 and 1961.

Many of the anomalies discovered proved to originate from well exposed unfractured rock areas and are probably due to segregations of radioactive accessory minerals. Extensive anomalies in the granitic rocks, South of Illescas, are of this type. Some of the anomalies are however of greater interest.

Anomaly 12 (20). Valentines Mine Road, 6 kms from Junction with R.7

At this location a sharply defined anomaly giving a reading of 4 5 times background was found. Ground inspection revealed a highly radioactive source giving Gammameter readings of up to 700. An alignment of high radioactive values could be traced through the nearby pasture fields. The occurrence was grid mapped (Figure 4) and values were found to extend for 250 meters, clearly suggesting a vein structure although actual outcrop was only visible on the road. The possible extension beyond this mapped area has not yet been fully investigated.

Later laboratory examination and a chemical analysis by the CEA group suggests that the radioactive source is a thorium mineral, possibly allanite.

Despite this, the occurrence should be more fully investigated by systematic trenching and sampling, because an apparent vein structure of this extent carrying thorium - rare earth minerals may be of interest in itself.

Several other anomalies of possibly the same type were recorded on the entry road to Valentines mine (Figure No. 4).

To the east of Valentines village in the Department of Treinta y Tres a number of high anomalies were found which will require careful ground checking.

One anomaly of a different type was found a little to the northwest of this area in a sedimentary formation.

Anomaly 18 (20) 6.0 kms. South of Las Cañas on Route 6

The country rock in this area is a coarse-grained sandstone of Devonian age. Within this formation some highly ferruginous zones occur, one of which at Paso del Medio and known as the "Las Palmas" deposit reaches iron ore grade and has been the subject of earlier investigations by the Institute of Geology.

The "Las Palmas" deposit was not visited but on the nearby Las Cañas road one of the ferruginous zones gave a marked anomaly reaching 3.7 times background.

The radioactivity was found to emanate from irregular zones within the hematitite-limonite areas. Readings of up to 150 were obtained on the Gammameter.

Analysis of a small grab sample by the CEA group gave a value of 0.0169% U. Further investigation of the anomaly is required and also the examination of the other ferruginous zones in this sedimentary formation, including the "Las Palmas" iron ore deposit.

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4. La Paz - Las Piedras Area

During the general reconnaissance survey, unusually high radioactivity was noted on many roads immediately surrounding Montevideo and the cause of this was traced to roadstone originating from quarries in the La Paz - Las Piedras area about 15 to 25 kilometers north of Montevideo, where there is a small area of Pre-Cambrian granite extensively opened up by roadstone and building stone quarries. The granite is coarse-grained, frequently kaolinised and hematitised and very broken. Some north-south trending basic dykes occur and although there are well marked joint planes, there are few faults or hydrothermal veins or signs of metallisation.

There is a high road density in the area and after a preliminary survey a detailed map of the radioactivity was made using aerial photographs as base. A complementary geological and structural map has been completed by Q.I. Jorge Bossi. Twenty anomalies were found, mainly within the roadstone quarries.

There is no marked increase in radioactivity in the few veins and faults which exist and in at least one case, high anomalous radioactivity (140 on the Gammameter) is clearly associated with a segregation line of dark coloured minerals in an exposure of unaltered granite. A thin section of this material studies by Q.I. H. Goso in the Institute of Geology showed a marked concentration of allanite and zircon.

Further work tended to confirm that all the anomalies were of this type and the lack of host structures, the lack of concentration of radioactivity in structures, the absence of the common secondary uranium minerals and the absence of metallisation, are all unfavourable for the discovery of economic uranium deposits.

The field studies already completed should however be complemented with mineralogical, petrological and chemical examinations to determine the exact origin of the anomalies.

5. Other Areas

Granites - Granites of a type similar to the La Paz-Las Piedras granite, and possibly of the same age, occur in several other parts of the country and show somewhat similar anomalous radioactivity. On the east coast, about 30 kilometers from the Brazilian border, there is the Santa Teresa granite on which is located the historic Santa Teresa fortress and a national park. The park roads and surrounding area were surveyed and four low-scale anomalies were located.

To the north-west of Montevideo one anomaly was found in the Sierra de Mahoma granite.

The anomalies located appear to be similar to those at La Paz-Las Piedras.

The most northerly anomalous area found was in and around the town of Mines de Corrales north-west of Tacuarembó. The rock is a red-pink granitic gneiss, slightly altered and with some quartz veins. All the roads within this granite gave continuous anomalous radioactivity, varying between 25 and 45. No complete inspection of the area has been made but the radioactivity again appeared to be general rather than specific.

Sediments - Except for Anomaly 18 (20) mentioned above, the only other anomalies found in sediments by the carborne scintillometer are two immediately south of the town of Melo. Anomalies 4 and 5 (16) are located in the San Gregorio formation at the base of the Gondwana sediments. Both anomalies are in red-coloured, finegrained sandstones, not very distant from the basal conglomerate of the San Gregorio. No specific structures were seen but further work will be required in this area to determine the extent of the anomalies.

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Anomaly 1 (15) Paso de Las Piedras. Bridge over the Rio Negro on the Railway line from Sarandí del Yi to the North

As mentioned earlier, a large well arrange drill sample store exists in the Institute of Geology. The expert had recommended in the first monthly report that these samples should be checked for radioactivity by scintillometer, but at that time no suitable instrument was available and it was not until the arrival of the CEA group, bringing portable scintillometers that the work could be started.

Almost at the first test by the Survey Officer and the CEA geologist, radioactivity was recorded in one group of samples which were traced in the records to engineering foundation holes drilled for the study of a railway bridge project over the Rio Negro on the Sarandí del Yi line in the Department of Durazno. The drilling work was done in the early 1940s and while the embankment and concrete support pillar on the south side of the river (which at this point is over two kilometers wide, including alluvial flats) and some of the support pillars for the bridge were built, the work was never completed and the railway terminates at Parada km. 329, about 1.8 kilometer south of the projected bridge.

Of the 35 holes drilled in the study, four only showed traces of radioactivity and these are closely spaced under the toe of the embankment at the south side of the river. Five holes Nos. 1, 33, 34, 35 and 36 form a diamond shaped pattern with diagonals of 25 and 30 meters, as shown in Figure No. 6.

Hole No. 1 shows no radioactivity but the other four holes show radioactivity varying up to seven times background on the scintillometer. Maximum values were noted in holes 34 and 35. One chemical analysis carried out by the CEA group on a small portion of a high activity sample from hole 35 gave a value of 0.30%U.

The radioactivity appears to emanate from a dark powdery material in the light grey siltstone. No bright coloured secondary uranium minerals are visible nor have bright coloured uranium sulphates grown on the samples in the twenty-five years of storage.

From a study of the scintillometer and analytical results carried out by M. Grimbert, the radioactivity appears to range between five and seventeen meters depth; the greatest width in any-one hole being approximately nine meters. The original drill samples are however small and were taken at half-meter intervals so that some doubt remains about exact locations and continuity.

The expert has made two visits to the area, firstly with Q.I. H. Goso and secondly with M. Grimbert and Q.I.J. Bossi. The car-borne scintillometer was unable to approach the toe of the embankment but did register a rise in radioactivity to a reading of 23-24. A small dump of material which had most probably been extracted from the excavation made for the support pillar showed radioactivity of six times background on the Gammameter. About a hundred meters south of the support pillar an outcrop of grey siltstones gave a reading of three times background.

The country rock is mainly fine-grained sandstone and siltstone of lower Permian age and is well exposed in the railway cuttings immediately to the south.

The evidence of the radioactivity in the drill holes and at the site and the one chemical analysis of a sample is undoubtedly favourable to the existence of uranium mineralization at this locality.

Both M. Grimbert and the writer have recommended to the counterpart organizations that the most important immediate requirement is to repeat drill holes as close as possible to the earlier holes to confirm and de-limit the radioactive zone with more exactitude and provide sufficient sample material for analysis.

Owing to administrative difficulties it was not possible to get a drill up to the site before mid-December and thus no confirmatory results could be obtained before the preparation of this report.

The carborne scintillometer has since carried out a number of traverses in this general area as shown on Figure No. 1 but no other anomalies have been discovered.

The CEA group will carry out a geochemical sampling programme over the immediately surrounding area during December.

The extent and value of this occurrence is not yet known, but it is undoubtedly of importance, possibly in itself, but certainly as a positive indication that uranium may occur in Devonian-Gondwana sedimentary formations in Uruguay.

GENERAL DISCUSSION OF RESULTS

The results of the 1965 survey, chiefly designed to assess the radioactive minerals possibilities in a country where little previous work had been done, must be considered as successful.

Over 100 radioactive anomalies have been found, principally in crystalline basement rocks and granites, but significantly, four have been found in sedimentary rocks. All of these except one have been discovered by the carborne scintillometer survey.

Although few of these radioactive anomalies may in fact lead to sizeable uranium occurrences, and many may be due to segregations of radioactive thorium minerals, it is nevertheless a normal technique to localize concentrations of anomalies in order to define if, and where, further work should be done. In this case the density of anomalies discovered is very high.

If the carborne scintillometer is considered to have an effective range of about 100 meters on each side of the instrument, then the 7,720 kilometers surveyed represents only an approximate 1,540 square kilometer sample of the whole country or about 0.83% of the total area. The discovery of 112 anomalies in the sample area is high and encouraging for further prospection work.

It may be of interest to indicate results from another country where the main types of geological formations are generally similar to those of Uruguay and where a seven year uranium prospecting programme, mainly by aerial scintillometer survey was 80% complete and all anomalies found had been checked and deposits prospected and evaluated.

TABLE 1.

RESULTS OF SEVEN YEARS WORK IN A COUNTRY
WHERE PROSPECTING WORK WAS NEAR COMPLETION

HOST ROCK TYPE	Anomalies discovered (2.5 x background) (aerial and carborne surveys)	Anomalies Recommended for further work	Anomalies proved to have exploitable uranium reserves	Percentage of total tonnage of uranium metal finally proved
1. Crystalline basement rocks and granites	276	44	6	11.7
2. Sedimentary rocks (mainly Tertiary)	168	10	:6	88.3
3. Volcanics (Mainly Tertiary)	140	1	0	0
TOTALS	584	55	12	100.0

Percentage of land area of country completely surveyed = 80.0%

At the end of one year's reconnaissance survey, the equivalent situation in Uruguay might be stated as follows:

TABLE 2

RESULTS OF ONE YEAR'S WORK IN URUGUAY

HOST ROCK TYPE	Anomalies discovered (2.5 x back-ground)(Car-borne Survey)	Anomalies checked	Anomalies recommended for further work	Anomalies proved to have ex-ploitable uranium reserves
1. Crystalline basement rocks and granites	108	50	18	0
2. Sedimentary rocks (Devonian to Recent)	4	4	4	0
3. Volcanic rocks (mainly Neo-Gondwana)	0	0	0	0
	112	54	22	-

Percentage of land area of Uruguay surveyed (approx.) = 0.83%

The comparison between these two tables shows two principal points: 1) The encouraging position in Uruguay at the end of only one year's work and 2) The amount of work which remains to be done before a full assessment of the nuclear raw material potential of the country could be made.

In the case quoted above in Table I, the largest and most economic reserves were eventually proved in Tertiary sediments, but it was clear that the uranium had been derived from nearby hydro-thermal veins in the crystalline basement rocks. The discovery of the sedimentary deposits had resulted directly from the de-limitation of zones of high incidence of anomalies in nearly crystalline base-ment rocks.

A possibly similar pattern is beginning to emerge in Uruguay where the more interesting occurrences in sediments apparently lie on a line of high anomalous radioactivity and metallisation running north-south across the country in the basement rocks.

The radioactive anomalies discovered are almost confined to the eastern half of the country bounded by a line running north-south from near Piriápolis through Minas, Sarandí del Yi and Minas de Corrales to Rivera. The only other significant metallisation in Uruguay follows the same line (Figure No.2).

The high incidence of anomalies, some of which may be of potential value in themselves, the many other remaining to be checked, plus the encouraging occurrence of uranium at Paso de Las Piedras suggests that there is technically a good case for a more detailed and complete programme of nuclear raw material prospecting in Uruguay.

RECOMMENDATIONS

The technical recommendations arising from the results of the work of 1965, fall under two categories:

1. An Immediate Continuation Programme for 1966, and
2. A Long-Term Programme for the Prospection and Development of Nuclear Raw Materials.

1. Immediate Continuation Programme for 1966

(a) All the radioactive anomalies which have been found during 1965 and which have not already been checked should be examined in detail and selected as either of no further interest or indicated for further work.

(b) Some anomalies have already been indicated in the records as requiring further work, either grid mapping, trenching or mineralogical study and this work should be organized and completed.

(c) When the IAEA permanent carborne scintillometer equipment arrives in substitution of the hired equipment, then systematic surveying of all roads and tracks on Sheets, 15, 16, 20, 21, 25 and 26 should be done. As a second programme, similar systematic surveying should be done on Sheets 6, 7, 10, 11, 12 and 17, and as a third programme on Sheets 8, 13, 18 and 23.

(d) Certain specific areas should be surveyed on foot on widely spaced (250 meters) traverse lines, plotting both geology and radiometric readings.

The areas recommended are as follows:

i An area of 1,000 square kilometers between Minas and Aiguá, including the Villa Serrana area and the Anomaly 1(25).

ii The area lying immediately north of Rocha.

iii The Valentines area. The area of principal interest is that shown in Figure 4(a), but should be extended to about 10 km east of Valentines village.

iv The Devonian sedimentary area of Las Cañas-Las Palmas, including the Anomaly 18 (20).

v The Minas de Corrales area, covering the granite but extending eastwards and westwards to cover the iron ore deposits and the old gold mine area.

vi A small area immediately south of Melo covering Anomalies 4 - 5 (16).

vii The Paso de las Piedras area will be surveyed by geochemical methods by the CEA group, but there is also a requirement for general 250 meter spaced traversing over a wider area.

(e) Paso de las Piedras drilling programme. A confirmatory drilling programme on the Paso de las Piedras occurrences is an immediate requirement. If the first test holes give positive results then these should be followed by an expanding grid of holes until the occurrence is fully defined.

(f) Mineralogical, petrological and chemical examinations should be made of material from all significant anomalies, especially to distinguish uranium mineral or thorium mineral causes of the radioactivity.

This immediate continuation programme will provide work for at least six months and probably the whole of 1966 using only the presently trained staff, the existing transport facilities, the existing and impending radiometric prospecting instruments (including the CEA equipment on loan for a year) and at a monthly cost of the same order as has been incurred during the period June-December 1965.

The counterpart officers Q.Is.H. Mujica, H. Goso, J.Bossi are fully competent to organize and execute the programme with the aid of the existing trained junior personnel.

2. Long-term Programme for Prospection and Development of Nuclear Raw Materials

The immediate continuation programme for 1966 should be regarded as only a temporary phase while consideration is given to the future policy of nuclear raw materials prospection and development in Uruguay.

The work of 1965 has proved that a technical case has been made out for a larger long-term programme but the policy on whether such work should be done at this time, its extent, future national value and how it might be executed, administered and financed must be considered.

In order to assist on this matter of policy the expert has first set out some of the presently known factors in world supply and demand for nuclear raw materials and secondly outlined the administrative requirements of a possible working organization before considering the actual long-term technical programme.

Nuclear Raw Materials, World Supply and Demand

Uranium

Production of U_3O_8 in the western world in 1964 amounted to 27,000 tons showing a continuous decline from 1959-60 when a peak production of 41,000 tons was reached. Production is expected to continue to decline to about 14,000 tons in the early 1970s. The reason for this is the lack of demand and not shortage of supply.

Nearly all this uranium will be produced against long-term contracts and there appears to be little opportunity for sales of uranium from new sources up to early 1970s.

The U.S. Atomic Energy Commission estimates that the total western world uranium reserves available at US$ 8.00 per pound in 1971 will amount to 474,000 short tons. This figure compares with an anticipated demand for the years 1971-1980 of between 250,000 and 365,000 tons and progressively greater demands in the decades 1980-1990 and 1990-2000, to keep pace with forecast rapid increase in installation of nuclear generating capacity.

It is therefore forecast that from the early 1970s onwards the prospection, development and production of uranium will have to be accelerated to keep pace with increasing demand and declining known reserves.

There already appears to be some desire on the part of consumers to negotiate long-term contracts with the objective of securing adequate supplies for the more distant future at fixed prices determined by the present weak market conditions. Some of the few recent contracts which have been made have been as low as US$ 4.00 per pound U_3O_8. The probable contract prices which could be made from the present time into the early 1970s would be in the region of US$ 4.00 to US$ 7.00 per pound U_3O_8.

Although the uranium mining industry can be regarded as being to some extent in the doldrums and may continue so into the early 1970s it seems certain that the demand in the future will rise rapidly.

Uranium prospecting in Uruguay should be considered against this background and deposits found should bear economic comparison with these in the rest of the world.

Thorium and Rare Earth Elements

Long-term forecasts seem to indicate that both the fast breeder reactor and reactors on the thorium and uranium cycle may become more competitive with uranium. That there is much support at the present time for the future development of reactors employing the use of thorium is evident from programme plans in the UK, USA, France, Germany and the USSR.

Thorium has also, of course, a continuous commercial demand for other industrial uses.

The year 1964 witnessed a marked increase in the production of rare earth with emphasis on the cerium group and a great deal of research is being conducted to evolve new processes for the extraction and separation of these elements and their future looks progressively more interesting.

The known occurrences of monazite in the Uruguayan beach sands and the possible occurrences of thorium and rare earth minerals in the Valentines and Minas areas should be carefully assessed and evaluated against this possible future increasing demand.

General Policy

The first decision which should be taken at a high Government level is whether, and to what extent and end, Uruguay should conduct a long-term nuclear raw materials prospecting and development over the next few years.

Once embarked upon, any programme such as outlined below, must be regarded as one which will extend for some years and will involve an expenditure of at least some hundreds of thousands of US dollars.

Such a programme would not necessarily be successful in proving economically workable uranium deposits and if uranium were found, it would be of no interest unless it could be produced at a price below or comparable with the then existing world market prices. Up until the early 1970s there is unlikely to be any commercial outlet for uranium unless at a price favourable to a consumer on a long-term contract. In the post mid-1970s there are some signs of a more hopeful commercial demand. For national consumption in future nuclear

power stations, the U_3O_8 concentrate is a comparatively minor cost item in the finished nuclear fuel but it would nevertheless be a saving in international currency.

On the other hand the initiation of a long-term prospecting programme in 1966 with a five to seven year prospecting period and a further period of some years for the development of deposits through to the production stage, may well be very correct timing if the mid-1970 increased demand eventuates. These matters should be fully considered, possibly with the aid of nuclear reactor and nuclear fuel experts whose assistance might be requested from IAEA on a short-term consultant basis.

If, after these aspects are considered, the decision is taken to go ahead with a long-term programme, then the expert would recommend that a new organization be set up to conduct the programme.

Existing Organization

The 1965 programme, both the one-year IAEA general reconnaissance programme now reported upon and the French CEA three-month geochemical prospecting and training programme have been sponsored by the Comisión Nacional de Energía Atómica (CNEA).

The CNEA is a non-executive committee formed by representatives of the University Faculties, various Ministries and several of the national autonomous administrations. The function of the CNEA is essentially coordinative as it does not itself possess laboratories, staff or adequate funds to carry out work in its own right.

Both the IAEA and the CEA programmes have been housed in the Geochemical Section of the Faculty of Chemistry. Staff for both programmes have been drawn from the Faculty of Chemistry, ANCAP, the Institute of Geology and the Faculty of Agriculture when possible and frequently on a part-time basis. Services have also been provided by the associated organizations on a petition basis and sometimes with difficulties. At various times, transport has been provided by ANCAP, the Faculty of Agriculture, the Institute of Geology and the Army. The drilling at Paso de las Piedras will be done by the Institute of Geology.

Until near the end of 1965, when a small direct vote was made for practical operations, the CNEA could not call on any direct funds of its own.

The administration of the reconnaissance programmes has been extremely loose and no one full-time counterpart officer with full responsibility has been assigned to the project as technical director.

While it has been possible to fulfill the reconnaissance programme under these conditions, it would be completely impossible to

contemplate entering into a long-term and expanding nuclear raw materials prospection and development programme with this type of organization and administration.

None of the associated organizations as at present constituted are entirely suitable, for one reason or another, to undertake such a programme.

Recommended Type of Organization

If a long-term programme is to be done then it is the expert's opinion that an entirely new organization should be set up to execute it.

Ideally this should be a raw materials department or directorate of a reorganized and executive National Atomic Energy Commission, such as exists in France, Argentina, Portugal, etc.

The Atomic Energy Commission would then be an executive organization with a full time President responsible only to a high Government level and drawing adequate funds, to finance its own research and operational projects in its own laboratories and installations.

The Nuclear Raw Materials Department or Directorate should be one of the Departments within the Commission with a Director responsible only to the President of the Atomic Energy Commission. The choice of this Director would be very important and should be a person of considerable administrative experience and a broad knowledge of all aspects of geological prospecting through to mining operations.

The problem of finding sufficient trained staff for mineral procurement programmes in Uruguay is considerable. As noted under "Fellowships" the Agency could materially assist by providing fellowships for the advanced study of mineral evaluation and programme direction as well as for specific technical posts. Relevant to this matter, the expert was invited to serve on a Mineral Resources Development Committee of CIDE (Comisión para Inversiones y Desarrollo Económico) during the year and produced a memorandum for that Committee which, with permission of CIDE, is reproduced as Appendix No. 2 in this report.

The Nuclear Raw Materials Department could then be planned and built up by the Director on the lines suggested below against an initial capital budget and annual capital and operating budgets.

Some fairly simple but essential organization matters should be aimed for to help ensure success, such as simple vertical line responsibility, full-time well remunerated staff and the financial independence of the organization for the purchase of capital goods and services.

The presently trained staff, mainly from the Faculties of Chemistry and Agriculture, ANCAP and the Institute of Geology should be invited and encouraged to become part of the full-time staff of the new organization.

If a new organization of this type were not possible then a nuclear raw materials department of ANCAP would be the next best solution.

RECOMMENDED TECHNICAL PROGRAMME

All metalliferous raw materials which eventually come on the market as usable final products have gone through four earlier phases: 1. Discovery; 2. Assessment and Economic Evaluation; 3. Development and 4. Production.

A long-term programme for nuclear raw materials is only concerned with the first two of these at the present time:

1. Discovery

Discovery may be effected by aerial or carborne scintillometer survey, ground prospection with instruments, geochemical surveys, indications from checking on museum or drill sample stores, etc.

Of these, the aerial scintillometer survey method is by far the most rapid, efficient and complete and should normally form the basic method in any national nuclear raw materials survey.

The carborne method is correctly a preliminary assessment tool and has been used very effectively as such in 1965. It may also be used in checking less favourable areas because of its lower cost.

Ground prospection is needlessly slow, laborious and possibly ineffective on a national scale but is extremely useful in covering selected high anomaly areas.

Geochemical methods are again for special areas where, because of some reason such as deep soil cover there is reason to believe that aerial scintillometer methods may not be completely effective.

Sample checking should, of course, always be done where such samples exist.

2. Assessment and Economic Evaluation

Assessment starts with the verification of the anomaly on the ground and if found to be of interest may be succeeded by: surface mapping, trenching, drilling and/or mining exploration with systematic sampling and assaying.

Economic evaluation involves a complex series of calculations to establish provisional cut-off grades, calculation of average grades, estimation of ore tonnage and U_3O_8 content of ore body, amenability testing of the ore, calculation of possible recovery factor, provisional mining and treatment methods, and cost of possible installation and working method.

All these calculations and estimates are necessary to reach a first estimate of the cost per unit of the final product. If the calculated cost per unit did not lie within the range of present or projected world prices or national economic requirements then the deposit could not be considered for the further stages of Development and Production.

In completed exploration programmes for nuclear raw materials in other countries it has been found that the time required from the start of the discovery phase on a national scale up to the economic evaluation of deposits is likely to be about five years.

The following long-term programme is therefore suggested as suitable for application in Uruguay. Modifications would, of course, be necessary as results were obtained and it must be strongly emphasized that such a programme is phased, so that no major expenditure is made on a succeeding phase until sufficient positive results are proved on each preceding phase.

The operating cost estimates are approximate, intended to suggest an order of magnitude for minimum success at each phase. Obviously, if very marked success were achieved in any phase the expenditure on succeeding phases would become very much greater. A similar situation applies to the personnel requirements.

PHASE I - Reconnaissance Carborne Scintillometer Survey, 1965, 1966 and possibly succeeding years

The carborne scintillometer should be used in the same way as in 1965, to find favourable areas for more detailed prospection either by air or by foot. It may also be used in later years to check unfavourable areas and eliminate them from the more expensive survey schemes.

Personnel requirement - 3 (2 operational and 1 at headquarters)

Operating costs - US$ 5,000 per annum

PHASE II - Aerial Scintillometer Survey 1966, 1967 and succeeding seasons

Modern aero-radiometric equipment provides the most rapid, effective and complete method of finding surface radioactive anomalies

and should be used as the main tool in any national campaign. As it is relatively expensive it should first be used in favourable areas delimited by the carborne surveys and geological considerations.

The Uruguayan terrain is particularly suitable for aerial survey work, having few sharply contrasting elevation changes, few forested areas but nevertheless sufficient features to make ground identification possible and sufficient outcrops and thin soil areas to make the method viable and efficient. Climatic conditions in the summer-autumn period are also ideal for this type of work.

Good aerial photographic cover of all the areas to be surveyed is however required and this is not at present available. The photographic cover on a 1:20,000 scale is now being done in the Minas-Aiguá area by the Uruguayan Air Force and it would have to be extended to cover the other areas recommended.

The areas recommended for survey in the first season are shown on Figure No. 3 and are briefly described below. The recommended priority of work is in the order stated:

I. The Devonian and Permian formations covering the same type of rocks as at the Paso de las Piedras occurrence, the anomalies south of Melo and the anomaly near Las Cañas, being part of sheets 15, 16, 17 and 12 and totalling approximately 12,000 square kilometers.

II. The Piriapolis-Minas-Aigua-Velazquez-Rocha area, covering parts of sheets 25, 26, 30 and 31 and amounting to approximately 8,500 square kilometers.

III. The Valentines-Treinta y Tres area in sheets 20 and 21 amounting to 3,500 square kilometers and adjoining the southern boundary of area I.

IV. An area surrounding Minas de Corrales in sheet 10 and amounting to 2,000 square kilometers.

V. A Cretaceous-Tertiary area between Salto and Paysandú covering Quebracho and some sub-anomaly areas found on Route 26. This is in sheet 8 and amounts to 2,000 square kilometers.

The total area recommended in the first instance is approximately 28,000 square kilometers or 15 per cent of the land area of Uruguay. Surveying is normally done at about 200-300 meters elevation on parallel traverse lines about 400 meters or quarter of a mile apart.

The recommended programme is equivalent to approximately 45,000 flying miles and with positioning this might reach 50,000 miles and would normally be considered as a one season, four to six month programme.

Suggestions are made under "TECHNICAL ASSISTANCE" about provision of aerial scintillometer equipment and experts to train or operate the programme. Unless given to outside contractors the aircraft

would have to be provided within Uruguay, most probably from the Uruguayan Air Force. On present enquiries it is stated that chargeable flying costs would be of the order of US$ 1.00 per flying mile, which is in agreement with the expert's figures for similar type of work in other countries.

(It might be mentioned that a survey done by a contractor, but including everything up to the delivery of final maps with anomalies located on them would be more likely to range between US$ 4.00 and US$ 6.00 per flying mile). There is thus strong reason for using IAEA or other foreign aid for this work.

The above is a one-season programme and depending on results found, similar sized programmes might be drawn up for following seasons.

The personnel required in addition to foreign technical experts and the aircraft flight and maintenance crews would be: two geologists, two technical assistants, two draughtsmen and an electronic servicing engineer, seven persons in all and this provides two teams for shift work with the aircraft. One support vehicle is also necessary.

Personnel requirement	-	7
Operating costs	-	Dependent on local arrangements and inter-department accounting, but with minimum aircraft operating costs, hire cost of equipment and staff costs the total may be approximately US$ 70,000 per year.

PHASE III - Ground Field Work - 1966-1968

This phase of work may be divided into three types of field operation, the first two covering discovery work and the third the beginning of the assessment work.

(a) Geochemical prospecting of selected special areas.

(b) Detailed geological and radiometric mapping by close traversing of selected highly favourable areas.

(c) Checking and initial assessment of anomalies found by any of the above methods of discovery.

The extent of this survey will of course depend on the number of anomalies found and while this cannot be predicted the work of 1965 appears to indicate that the density will be high.

The principal requirements in this phase of ground field work will be staff, vehicles, radiometric instruments and laboratory equipment. A minimum estimate is as follows:

Personnel	- 25 mainly geologists and prospectors and laboratory staff
Annual Operating Costs	- US$ 50,000 mainly salaries, allowances and vehicle operating costs.

PHASE IV - Preliminary Assessment Programme - 1966-1969

Grid mapping and surface trenching and sampling of radioactive anomalies which have been assessed as being of probable greater interest is done in this phase. The principal requirement for this work is local casual labour.

Personnel	- 4 (1 chief geologist, three prospectors) plus a variable number of casual labourers.
Operating Costs	- US$ 10,000 per year.

PHASE V - Drilling Assessment

All occurrences which provide good positive results at the completion of the grid mapping, and trenching stages or for any other positive reason must be investigated in depth.

While it is very difficult to make any serious estimate of the work requirement in this phase it is already obvious that drilling at the Paso de las Piedras occurrence is necessary and this type of requirement may well increase as the programme develops.

Precussion drilling and rotary shot drilling may meet many requirements but other problems may require diamond drilling involving the purchase of such drills. Assuming for the present that drills can be hired through the Institute of Geology and charged on a per meter basis the minimum requirement would be:

Personnel	- 4 (one planning and assessment officer drill logging and sampling personnel)
Operating Cost	- (2,000 meters per year) Cost of support vehicle, etc. US$40,000

PHASE VI - Mining Exploration

Some occurrences, particularly in sediments can be assessed by drilling and mining exploration would be small. Other occurrences in hard rocks could only be finally assessed by mining work.

As there is no mining organizations in Uruguay the major factor in this phase would be the capital purchase of all necessary mining equipment. It would also be necessary to train or contract senior staff to conduct such work.

It is difficult to make any estimate for this but a very modest programme of 500 meters per year would approximate to an operating cost of US$ 50,000.

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All these work phases require considerable support by a head-quarters organization. Administrative offices, technical offices, chemical, electronic and mineralogical laboratories, drawing offices, records offices, maintenance workshops, etc., with adequate trained staff would be required.

No mention has been made of capital requirements because it is not known how far vehicles, etc. might be provided by existing organizations in Uruguay.

If a new organization were to be set up the main items in a minimum requirement might be:

- Headquarters offices with complete office and laboratory equipment;
- An aircraft (probably hired)
- 10 to 12 vehicles, jeeps or pick-up trucks
- One set aerial scintillometer equipment (probably hired)
- One set carborne scintillometer equipment (IAEA contribution)
- 6 field scintillometers } partly contributed
- 10 field ratimeters } partly contributed
- 2 sets borehole logging equipment
- 4 drills including one diamond drill
- Mining equipment, compressor, drills, pumps, ventilators, etc.

Even allowing for hired and contributed equipment, the minimum probable expenditure on these items would be of the order of US$ 250,000.

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In terms of time and operating cost, the programme might be approximately as indicated in Table 3. Table No. 4 indicates a possible organization plan.

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In summary, a long-term programme for the prospection and evaluation of nuclear raw materials, assuming at least minimum success at each phase, is likely to last about five years, involve an operating expenditure of up to US$ 600,000 and a capital expenditure of US$250,000 and to require at its maximum a trained staff of up to 45 persons.

If the total cost of the above programme were to be amortized at the rate of 10% of the value of the eventual production, then "minimum success" means the discovery of approximately 500 tons U_3O_8 which could be recovered and produced at US$ 8.00 per pound U_3O_8. This is not a large tonnage in terms of discoveries in other countries and would tend to be an encouraging factor when considered against present indications.

TABLE No.3

LONG TERM PROGRAMME FOR PROSPECTION AND EVALUATION OF NUCLEAR RAW MATERIALS

Cost Estimate for "Minimum Success" at each Phase

	1965	1966	1967	1968	1969	1970	Total Estimate Cost per Phase, US$
PHASE I							
Reconnaissance Carborne Survey							10,000
PHASE II							
Aerial Scintillometer Survey							140,000
PHASE III							
Ground Field Work a) Geochemical Surveys b) Geological & radiometric mapping c) Checking of anomalies							100,000
PHASE IV							
Grid mapping and trenching							40,000
PHASE V							
Drilling							160,000
PHASE VI							
Mining Exploration							150,000
Approximate Annual Operating Costs US Dollars	5,000	60,000	110,000	125,000	150,000	150,000	
Cumulative Operating Cost	5,000	65,000	175,000	300,000	450,000	600,000	600,000
Senior Staff Requirements	6	20	40	45	45	45	

TABLE No. 4

ORGANIZATION PLAN FOR
LONG-TERM NUCLEAR RAW MATERIALS PROSPECTION AND EVALUATION PROGRAMME

Director

- Foreign Technical Assistance Adviser
- Headquarters Evaluation Group

- Initial Prospecting Group (Discovery Group)
  Group Director
  - Carborne Scintillometer Survey
  - Aerial Scintillometer Survey
- Geological Field Group
  Group Director
  - Geological & Radiometric Field Mapping
  - Anomaly Checking
- Administration
  Transport, etc.
- Headquarters Laboratories
  Group Director
  - Chemical
    Mineralogical
    Electronic
    Laboratories
    Survey Dept.
    Sample Preparation etc.
- Operational Group
  Group Director
  - Trenching
  - Drilling
  - Mining
  - Workshops

Geochemical Prospecting (between the Geological Field Group and the Headquarters Laboratories)

The growth of an organization is dependent on results, but it must be visualized that if successful results are obtained then adequate equipment and facilities must be available to realize the full potential of discoveries.

In Argentina the CNEA started in 1958-59 with only six geologists and a small supporting staff and over a period of some seven years an organization of the type suggested above has grown up and now has some 60 geologists and hundreds of supporting staff.

In the same period the U_3O_8 reserves have risen from near zero to several thousands of tons of fully evaluated U_3O_8 reserves.

Very similar organizations were built up over similar time periods in France, Spain, Portugal and other countries and the U_3O_8 reserves made equally spectacular increases.

TECHNICAL ASSISTANCE

During 1965 the Agency provided three Gammameter GMT.3T instruments and one accessory drill probe attachment on a permanent basis to the Uruguayan Government. The carborne scintillometer equipment which was hired through the Agency for the 1965 programme will be replaced by similar permanent equipment in early 1966.

The French CEA group brought nine scintillometers and Gammameters and laboratory equipment which will be left on loan to Uruguay until late 1966.

The combined total of this equipment is adequate to carry out the "Immediate Continuation Programme" for 1966 as outlined above.

The most immediate and major future requirement is for aerial scintillometer equipment to run the survey recommended above in the 1966-67 summer season.

The presently recommended area and even the continuation of the survey to cover 60% of the whole country, is not big enough to justify the outright purchase of a set of aerial survey equipment. It is therefore recommended that this should be hired, either through the Agency or other foreign organizations.

If it is intended to approach the Agency for assistance in this matter, then a request for the hire of a complete set of equipment and the assistance of an expert to train personnel and direct the programme for a period of six months starting October 1966, should be made as soon as possible.

In the meantime the Uruguayan authorities should investigate the provision of a suitable aircraft from the Air Force or other national body.

Another most convenient and practical possibility is in association with the Argentine CNEA. The expert has had a brief conversation with Dr. Pedro N. Stipanicic, Chief of the Raw Materials Directorate of the CNEA who indicated that such equipment was available in their laboratories and he felt that in principle, there would be no difficulty in its being utilized in Uruguay with technical operating assistance from trained Argentine CNEA aerial survey personnel.

Whether this possibility should be investigated directly between the Uruguayan Government authorities and the Argentine CNEA or whether IAEA could act as an intermediary is a matterfor discussion.

Dr. Stipanicic also indicated his willingness to receive Uruguayan visitors at the Nuclear Raw Materials Directorate. The expert would strongly recommend that if it could be suitably organized, a group of Uruguayan counterpart officers should spend a period of not less than one month with the Argentine CNEA Directorate of Raw Materials. The items to be studied would be, the present organization of the Directorate, its growth, financial and administrative structure, all headquarters technical departments and laboratories, methods and type of field work employed, radioactive anomalies, uranium occurrences, developed deposits and mines, evaluation processes, problems and results.

From the expert's brief talk with Dr. Stipanicic, there seems little doubt that such an invitation would be extended by the CNEA to a small group of Uruguayan officers.

In the expert's opinion, the year 1966, except for the immediate continuation programme outlined above, might most usefully be employed in arranging the financial resources and the administrative organization for a nuclear raw materials directorate in Uruguay so as to be able to start an expanded programme in late 1966 with the above recommended aerial survey. If a suitable permanent directorate had by then been organized then it is recommended that a request for a technical adviser for the whole programme be made to IAEA to cover the years 1967,1968 and 1969.

FELLOWSHIPS

As there is little of a mineral industry or tradition in Uruguay there is a considerable requirement for further education in mineral procurement and evaluation. The Agency could most suitably provide this through educational fellowships.

In the expert's opinion the principal requirement would be at the higher level of the administration and organization of mineral procurement programmes with technical emphasis on assessment and evaluation methods.

The present counterpart officers, Q.Is. Jorge Bossi and Hector Mujica could most suitably benefit from fellowships of this nature and the possibility of a more extended study with the Argentine CNEA should be investigated. Studies in France or in any other country with an advanced nuclear raw materials prospecting organization would also be a feasible alternative. The objective of this type of fellowship would be to provide the higher directorate for a future long term nuclear raw materials prospecting programme in Uruguay.

Fellowships for education or specific technical levels, such as prospecting, drilling and mining should also be sought for after a long-term programme had been initiated.

MONAZITE-BEARING HEAVY MINERAL COASTAL SANDS

In the early 1950s the Division of Scientific Investigations of ANCAP (Pando Laboratories) made some preliminary investigations of the heavy mineral sands on the Uruguayan coast east of Montevideo. The interest was principally in the monazite content.

Between then and 1963 several general reconnaissance programmes were carried out on specific areas between Atlántida and the Brazilian border and also on some areas west of Montevideo and on the Rio Uruguay north of Salto. A hand-operated auger type drill was used to put down holes on fairly widely spaced lines.

The figures available from this reconnaissance programme, which is not claimed to have been complete, are as follows:

TABLE No. 5

ESTIMATED TONNAGES OF HEAVY MINERAL SANDS ON THE URUGUAYAN COAST
PRELIMINARY RECONNAISSANCE WORK

Location	Distance from Montevideo Kilometers	Percentage of Heavy Minerals	Estimated Tonnages of Heavy Minerals
Atlántida	50	11.9	21,700
La Floresta	60	9.3	3,600
San Luis	80	3.1	47,200
Las Flores	90	1.0	1,500
Bella Vista	95	8.3	88,000
Aguas Dulces	270	3.0	1,116,000
Punta Lobero	280	1.4	1,800,000
La Coronilla	300	2.33	17,000,000
			20,078,000

Aguas Dulces

In 1963 a systematic drilling programme was started at Aguas Dulces using a "Carpco" "Walking Beam" drill rig. The spacing of holes was on a 200-meter grid and covered an extensive area of Government owned land. The programme was brought to a close in October 1965.

The results at the end of September 1965 were as follows:

Number of Holes Drilled	481
Average Depth of Hole	6.54 meters
Total Meters Drilled	3,219 meters
Total Area Prospected	1,069 hectars
Number of Samples Analysed	2,146
Volume of Sands Outlined	69,885,000 cubic meters
Tonnage of Sands Outlined	118,804,500 tons
Average Heavy Mineral Content	2.54%
Heavy Mineral Content	3,019,300 tons

The cut-off value used was 1.0% heavy minerals. The mineralization is reputed to continue to the west of the area tested and no cut-off boundary of the deposit has been de-limited. Comparison between the preliminary reconnaissance programme and the systematic programme shows an increase in heavy mineral content by a factor of nearly three and a decrease in percentage content from 3.00% to 2.54%.

Testing of the Aguas Dulces heavy mineral concentrate gives the following results:

Minerals	% of total Heavy Mineral Concentrate	Chemical Analysis of Contained Elements
Ilmenite	60.0	T_1O_2 = 50.5%
Zircon	5.0	ZrO_2 = 65.0%
Rutile	1.0	T_1O_2 = 94.0%
Monazite	0.6	RO_2 inc. ThO_2 = 64.5% in which ThO_2 = 4.5% U_3O_8 = 0.26%
Silicates (Garnet, Epidate, Hyanite,etc.)	33.4	-

The mineral contents at Aguas Dulces are therefore of the order of 1,800,000 tons of ilmenite, 150,000 tons of zircon, 30,000 tons of rutile and 18,000 tons of monazite (the latter containing about 800 tons ThO_2 and 47 tons U_3O_8).

No systematic work at any of the other localities has been done. A new discovery in 1965, to the west of Montevideo, near Colonia Valdense, called Playa Fomento, appears to be high-grade and may become the subject of systematic prospection in the near future.

The present reserve situation therefore is that three million tons of heavy minerals have been proven at Aguas Dulces and that there is a good possibility of another twenty million tons in other coastal areas. The average content of heavy minerals is variable but generally low in comparison with deposits in other parts of the world. The overall ThO_2 and U_3O_8 contents may be of the order of 6,200 and 360 tons respectively.

The choice of Aguas Dulces as an area for systematic prospection was to some extent dictated by the fact of the area being Government land. The expert would suggest that the area has been somewhat over-prospected and that it might have been better policy to have done some systematic drilling on other areas where higher grade and greater proximity to Montevideo would have been favourable economic factors.

Considerable studies have been made at the Pando Laboratories on the concentration and separation of the minerals. Two series of studies have been made at foreign laboratories, one at "Carpco" laboratories, Jacksonville, Florida, U.S.A., and the other at the Centre de Recherches de la Cie. Pechiney, St. Gobain, Paris, France, the latter supervised by Q.I.H. Mujica, from the Pando laboratories,

The result of these tests shows that there would be no technical difficulty in obtaining high recovery and producing high-grade concentrates of the individual minerals.

A report on a pre-study of the economic possibilities of the Aguas Dulces deposit was prepared by Q.I. Ernesto Onetto and Q.I. Mario Benedetti in April 1965. Very considerable economic problems are forseen in this report. Two basic sets of operating plans were considered, the first assuming a production of 40,000 tons and the second of 120,000 tons of ilmenite per annum. Several variations on each of these basic tonnage programmes were considered such as, total export of all products to the U.S.A., export of ilmenite to the Argentine and the other minerals to the U.S.A., reduction of the ilmenite in Uruguay to produce iron and a TiO_2 slag for separate sale and export to the other minerals.

In only two of the calculated schemes was a profit shown--and in the majority of the schemes considerable apparent losses were calculated.

A significant set of figures given in the report (slightly adapted by the expert) are as follows:

	Percentage of Total Cost for the two basic schemes, assuming sale of all products to the USA	
	Scheme I 40,000 tons ilmenite/year	Scheme II 120,000 tons ilmenite/year
1. Amortisation (variable number of years 5, 10 and 20 on different items)	21.8	24.7
2. Labour and Management	24.6	12.7
3. Consumable Stores	7.4	8.7
4. Transport of products within Uruguay	12.5	14.6
5. Marine Transport including loading, taxes, etc. in Montevideo Port	33.7	39.3
	100.0	100.0

Approximately 40% of the last item is due to Montevideo Port charges and taxes. At the time of preparing the evaluation report (end of 1964) the calculated value of the mixed concentrate of heavy minerals was US$ 22.00 per ton or approximately US$ 0 50 per ton of sand on the ground. Due to a rise in the mineral prices the present (end of 1965) values are nearer to US$ 26,00 and US$ 0.60 per ton, respectively, but this has not solved the basic economic problem.

The fact that approximately 50% of the estimated costs is in transport of products, taxes and handling charges, is a most crippling factor and all the schemes which would tend to avoid or minimize this should be more fully investigated. The amortisation item also appears to require further study.

An independent re-assessment of production methods, marketing possibilities and all the economic factors appears to be called for.

The expert would strongly recommend that ANCAP request the assistance of an experienced heavy minerals consultant engineer through the International Atomic Energy Agency of the United Nations to make an independent survey of the whole problem and especially to advise on production costs and marketing, and if possible to initiate pilot plant production.

The full economic background of a potential industry with an apparent value in the ground of about US$ 500,000,000 should be most seriously and deeply examined.

ACKNOWLEDGEMENTS

In the first place the expert wishes to express his gratitude to Professor Ernesto Onetto, Dean of the Faculty of Chemistry of the University of Uruguay, for his friendly help and support, throughout the year, and for putting all the facilities of the Faculty of Chemistry at his disposal.

Sincere gratitude is also due to Professor Alfonso Frangella and Ing. German Villar, Chairman and Vice-Chairman, respectively, of the Comisión Nacional de Energía Atómica and to all the other members of the CNEA for assistance with the programme.

The expert also wishes to thank the Director of the Administración Nacional de Combustibles, Alcohol y Portland (ANCAP) and the Director of the Institute of Geology, for their support and assistance through the year.

The expert especially wishes to express his thanks to Q.Is. Héctor Mujica, Héctor Goso and Jorge Bossi, who acted as principal counterpart officers for the project throughout the year and accompanied him on field work. Thanks are also due to the other officers who carried out field work with the expert and assisted the work at the headquarters office.

TABLES SHOWING RESULTS OF CARBORNE SCINTILLOMETER SURVEY

TABLE 1

KILOMETRES SURVEYED AND ANOMALIES DISCOVERED PER 1:100,000 SURVEY SHEET
AT 10th DECEMBER, 1965

(Complete survey sheets cover 8,000 square kilometres. Incomplete sheets overlapping the borders of the country are indicated by "x")

Sheet No.	Sheet Name	Total Km. Surveyed	Anomalies Discovered	Anomalies Checked	Anomalies Recommended for further work
1. (x)	Bella Union	90	-	-	-
2. (x)	Artigas	141	-	-	-
3. (x)	Rincón de Pacheco	-	-	-	-
4. (x)	Salto	93	-	-	-
5.	Celeste	24	-	-	-
6. (x)	Rivera	101	-	-	-
7. (x)	Lapuente	-	-	-	-
8. (x)	Queguay	177	-	-	-
9.	Arerungua	117	-	-	-
10.	Tacuarembó	396	2	-	-
11.	Vichadero	15	-	-	-
12. (x)	Centurion	-	-	-	-
13. (x)	Paysandú	175	-	-	-
14.	Guichón	100	-	-	-
15.	Rincón del Bonete	344	1	1	1
16.	Melo	185	5	2	2
17. (x)	Rio Branco	-	-	-	-
18. (x) 18A.	Mercedes and Viscaíno	168	-	-	-
19.	Durazno	259	-	-	-
20.	Sarandí del Yí	361	20	6	4
21.	Treinta y Tres	337	14	3	2
22. (x)	Cebollatí	52	-	-	-
23. (x) 23A.	Rosario and Nueva Palmira	289	-	-	-
24.	San José de Mayo	397	1	-	-
25.	Minas	417	2	1	1
26.	Aiguá	440	26	14	6
27. (x)	Castillos	128	4	-	-
28 (x)	Colonia	63	-	-	-
29. (x)	Libertad	1124	20	14	1
30. (x)	Pando	939	12	11	3
31. (x)	Rocha	288	5	2	2
32. (x)	Cabo Polonio	-	-	-	-
TOTALS & AVERAGE		7720	112	54	22

The lower sheet numbers lie in the northern part of Uruguay and the higher numbers in the south.

APPENDIX 1

TABLE II

KILOMETRES SURVEYED AND ANOMALIES DISCOVERED RELATED TO GEOLOGICAL FORMATIONS

	Geological Formations	Total Km. Surveyed	Anomalies Discovered	Anomalies Recommended for further work
1.	Pre-Cambrian Crystalline Schists	2340	50	8
2.	Pre-Cambrian granitic gneiss and granites	1938	58	10
3.	Devonian sediments	165	1	1
4.	Eo-Gondwana. Carboniferous sediments	362	3	3
5.	Eo-Gondwana. Permian sediments	261	-	-
6.	Neo-Gondwana. Triassic sediments	146	-	-
7.	Neo-Gondwana. Retico-Liss Volcanics. Basalts	643	-	-
8.	U. Cretaceous sediments	465	-	-
9.	Oligocene. Queguay sediments	20	-	-
10.	Miocene - Pliocene sediments	285	-	-
11.	Pleistocene and Recent sediments	1065	-	-
	TOTALS & AVERAGE	7720	112	22

MEMORANDUM TO THE COMISION DE INVERSIONES Y DESARROLLO ECONOMICO (CIDE) COMMITTEE ON DEVELOPMENT OF MINERAL RESOURCES, PRESENTED IN MAY 1965

Introduction

The United Nations report entitled "Los Recursos Naturales en América Latina, su Conocimiento Actual e Investigaciones Necesarias en este Campo: I. Los Recursos Minerales", dated March 1963, notes that many countries in South America suffer from deficiencies of metals and minerals such as are essential for the progress and development of modern nations and that the cause of these deficiencies may be lack of geological and mining knowledge rather than a real poverty of metals and minerals in these countries.

The situation suggested is particularly applicable to Uruguay where the emphasis of the national economy has always been overwhelmingly towards agricultural products and little attention has ever been given to the possibility of developing mineral resources.

The fullest development of a country's mineral potential must always be to its advantage, whether the products are used for internal consumption or exported for foreign exchange or whether the work is done by a Government body or by private enterprise. It is therefore recommended that attention be given to a programme of fundamental studies, leading to the exploration and development of the mineral resources of Uruguay.

I. Inventory of Existing Information

The first step in any such programme should be an inventory of all the presently existing information on the subject. Such a report should cover the following points:

(a) The state of the geological mapping in the country.

(b) Summarize past prospection surveys for metals and minerals.

(c) List the past mining history and production records of all metals and minerals.

(d) List the presently estimated ore reserves and production costs of all products.

(e) Estimate the possible national requirements and consumption of metals and minerals known to occur in the country.

(f) Estimate the world marketing possibilities of such metals and minerals.

(g) Investigate the state of the various organizations involved in mineral work. This should list annual operating budgets, other financial resources, numbers and grades of staff, housing and equipment.

(h) The educational and training facilities for personnel likely to be employed in mineral resources work should be fully investigated.

The preparation of a report of this nature might take some months and would best be done by an independent consultant (either from a reputable international consulting company or from the United Nations) called in by CIDE and given complete access to all the available information.

On completion of such an inventory, the independent consultant would then be in a position to make recommendations about the required scope and scale of a mineral resources programme suitable for Uruguay.

II. Probable Objectives

On the basis of the recommendations of the inventory report the detailed future programme should then be worked out and cost estimated by Government Officers in collaboration with the consultant. It is possible that the programme might cover the following principal objectives:

(a) The preparation and publication of high quality basic geological maps of the whole country, conforming with international standards and on a scale of 1:50,000.

(b) The prospection for, and the evaluation of any possible metal and mineral resources in the country using all available modern methods for such work. The order of priority in such prospecting would appear from the inventory study and from the basic geological mapping. At the present time, the various categories of mineral resources and the possible priorities for additional work could be suggested as follows:

Metals	Non-metallics
1. Black sand deposits	1. Limestone and cement
2. Iron and Manganese	2. Building stone
3. Nuclear raw materials	3. Chemical group, phosphates, etc.
4. Precious metals. Gold, etc.	4. Fuels
5. Base metals, copper, lead, zinc	5. Ornamentals and semi-precious gems
6. Other metals	

(c) The development, exploitation, production and marketing of any mineral resources proved in the second stage. This might involve the actual operation being carried out by a national organization or the encouragement of private enterprise to invest in the mineral industry.

III. Organization

Such a programme could best be carried out by setting up, or re-organizing and re-equipping two national organizations.

Organization "A" would be designed to cover the basic geological mapping, the mineral prospecting and the preliminary evaluation programmes.

Organization "B" would cover the development, exploitation, production and marketing of the metal and mineral products and supervise and control any private enterprise production in this field.

Organization "A" would, in all probability, be the existing Instituto Geológico del Uruguay, expanded, rehoused, and re-equipped. In order to carry out even a minimum programme of the type envisaged, it is probable that the total staff would exceed 100 and that up to 50 of these would be graduate geologists, engineers and chemists. The housing and equipment would have to be of a standard and quantity sufficient to support a modern organization of this type. Sufficient funds should be available for the organization to operate up to a modern international standard and to enable it to call in consultants and foreign companies to run specialized surveys on contract.

The final terms of responsibility of Organization "A" would be taken to a point where a metal or mineral deposit had been discovered, outlined and assessed and probable ore reserves defined and the economic possibilities broadly outlined. Beyond that point, further development and exploitation would be handed over to Organization "B".

Organization "B", designed to cover the development to marketing phase could, most suitably be in the form of one of the already existing national organizations such as ANCAP. The technical staff would be mainly mining engineers capable of developing and operating any mineral property. Metal and mineral economists should also form part of the staff so that the products could be marketed in the most efficient manner.

Such an organization would be more flexible than Organization "A" as its size would depend on the number of mining properties operated. An essential requirement would be the ability to call on large capital resources for investment in mine development projects.

The eventual aim of such an organization would be to be self-supporting and profit-making.

Logically, the new organization should take over from ANCAP the Portland cement and black sand projects and add to that, similar developments of all other metal and mineral occurrences in the country.

In addition to being a nationalized operating organization, the possibility for private enterprise operation in this field should be allowed for and in such cases the organization should act as the equivalent of a "Bureau of Mines", promoting, controlling and legislating on private enterprise operations.

IV. Support Phase

Such a mineral resources programme pre-supposes several essential support projects. The two most urgent would be:

(a) Aerial Photographic Cover and Topographic Maps - At the present time, no up-to-date aerial photographs nor large-scale topographic maps of the whole country are available. This is an urgent requirement for many other purposes besides geological mapping. The need for such basic material in agricultural soil research, general agriculture, forestry, water resources and control, town and rural planning, transport and communications, etc. is considerable. The work might therefore be done on a national basis separate from the mineral resources programme, but the geological mapping visualized as an essential preliminary of the whole programme could not be done until such aerial photographs and topographic maps were available.

(b) Education and Training of Geologists and Mining Engineers - At the present time the University facilities and courses are quite inadequate to provide suitable staff for an expanded programme of geological activity and mining work.

A preliminary support phase of the whole project would therefore be the setting up of University facilities to train geologists and mining engineers. The present teaching facilities in this field should be reviewed and rationalized into one Department or Faculty for the teaching of geology, economic geology, mining engineering, mineral dressing and related subjects to cover all needs within the country. Assistance in setting up such new Departments has been provided by the United Nations in other countries and might be considered in this case.

It is obviously an urgent first step in a mineral resources programme as it would be at least four years after the start of the teaching programme before the necessary new staff was becoming available for the two organization.

V. General Policy and Legislation

The existing mineral resources laws and taxation structures should be reviewed to give encouragement and protection to a new mineral industry.

Besides the two organizations mentioned above, private enterprise should be encouraged to operate wherever possible in the mineral field. This could be controlled by legislation to allow for private mineral concessions and prospecting in addition to the work done by Organization "A". It should also be possible for private owners to develop and exploit properties parallel with Organization "B". On the other hand, lack of serious productive work by private owners would be penalized and an obvious piece of legislation would be that mineral concessions where no work had been done for a number of years would revert to the state.

Facilities should exist whereby Organization "B" could buy or sell or lease properties. Occurrences discovered by Organization "A" should automatically pass to Organization "B", but if it were not convenient for the latter to exploit them at that time, they could be offered to private enterprise. Both organizations should provide technical information and services to private owners for the development of their properties.

In some cases, Organization "B" might provide a garanteed market for products or be the only buyer at a subsidized price, merely to give initial encouragement to a young mineral industry. Government subsidy and controlled purchase of private gold production and nuclear raw materials would be the most obvious examples.

Summary - The development of a mineral resources programme for Uruguay might therefore have the following phases:

1. The making of an inventory report of all relevant information on mineral resources in the country at the present time.
2. Based on the findings of the inventory, a programme for the development of the mineral resources of the country would be drawn up.
3. The setting up of University training facilities to produce graduate personnel to staff the mineral resources programme.
4. The completion of aerial photographic and topographic mapping surveys in conjunction with other interested organizations.
5. The setting-up or the re-organization of an Organization "A" so that it would be capable of the geological mapping of the whole country and the prospecting for, and evaluation of, mineral resources up to the point of stating "probable" economic ore reserves.

6. The setting-up of an Organization "B" capable of developing, exploiting, producing and marketing the mineral resources of the country.

7. The review of legislation and tax structures so as to give encouragement to and to control any parallel private enterprise operations in the mineral resources field.

Note: The possibility of assistance from international organizations in this programme should be fully investigated. The items 1 and 2, above, that is, the taking of an inventory and the laying out of a detailed programme, would be particularly adapted for United Nations assistance. The setting-up of a new teaching department is another field where United Nations assistance could be sought for a long-term, five or six year teaching programme. Consultant assistance from a United Nations source might be useful in designing new legislation and tax structures for a new industry. The possibility of calling on specialized assistance in aerial photography, mapping and in various prospecting techniques should also be borne in mind.

Signed:

James Cameron
D.Sc. M.I.M.M.

19th May 1966

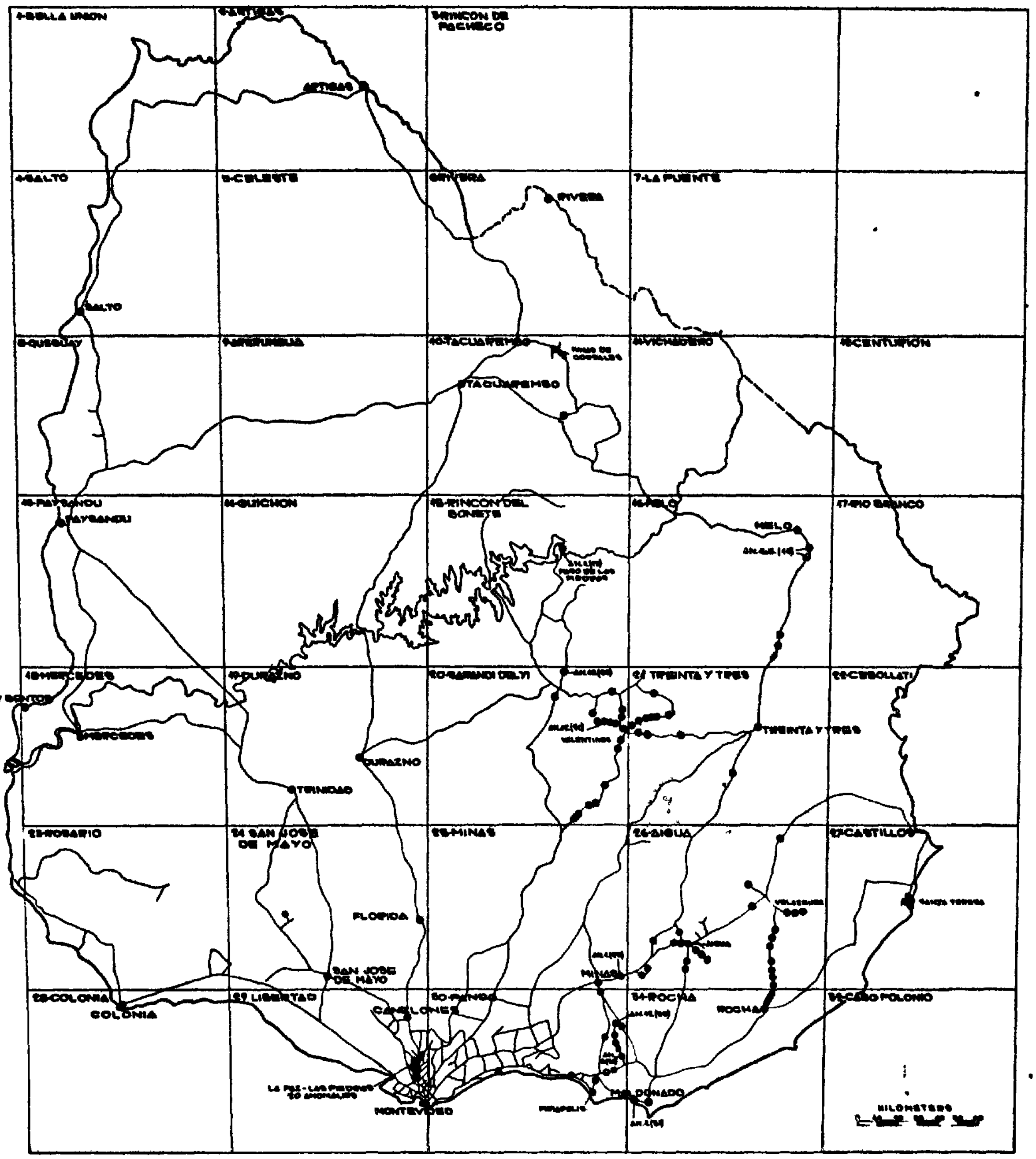


FIGURE Nº1

REPUBLICA ORIENTAL DEL URUGUAY

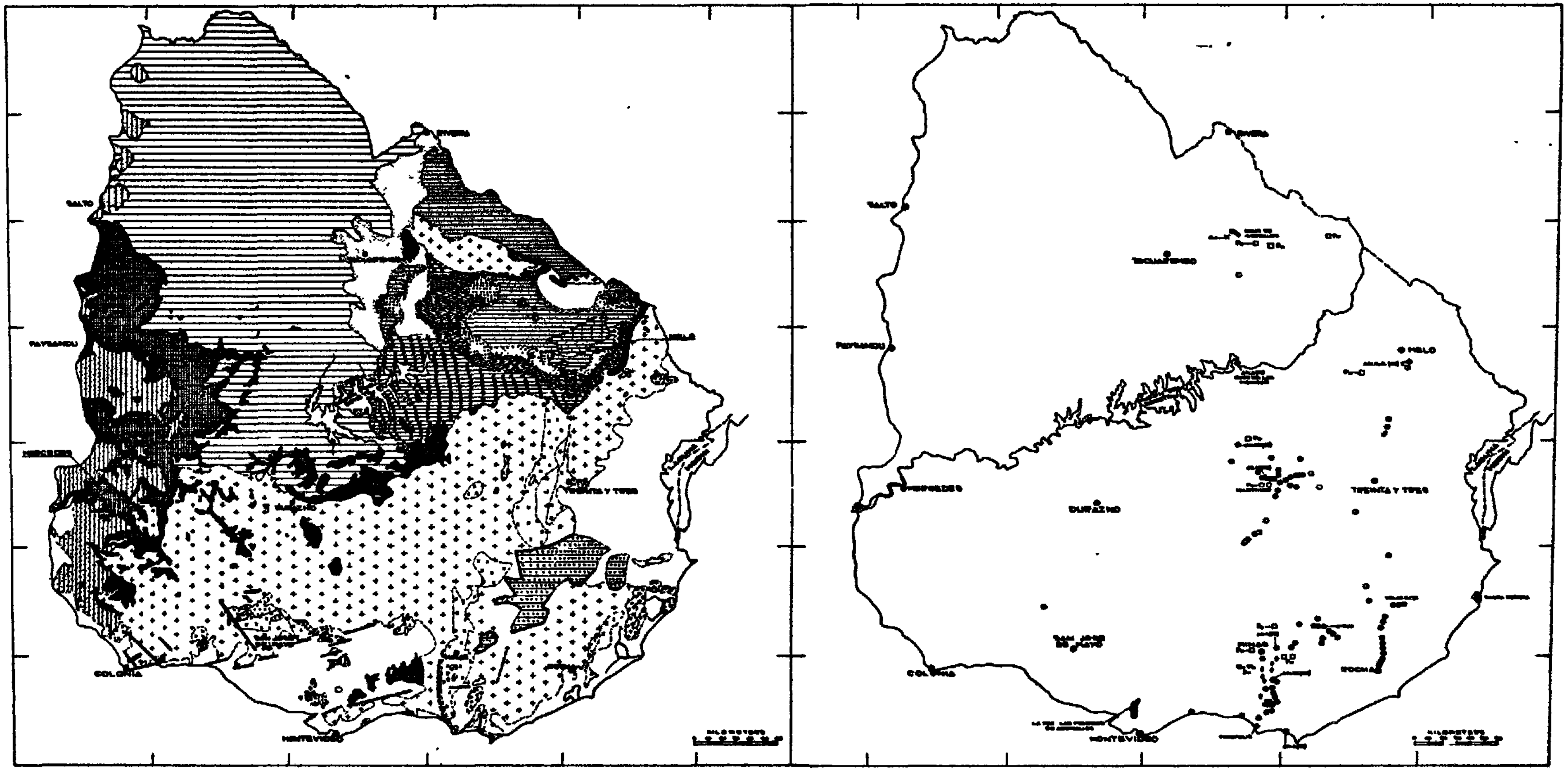
CARBORNE SCINTILLOMETER SURVEY 1965

ROADS SURVEYED

RADIOACTIVE ANOMALIES DISCOVERED

BASE MAP SHEET — 25 MINAS

SPECIFIC ANOMALIES MENTIONED IN TEXT AN.4(25)



A- GEOLOGICAL MAP OF URUGUAY
(FROM J.H.CAORSI - J.GOÑI - J.BOSSI - H GOSO)

PRE-CAMBRIAN — PALEOZOIC (EO-GONDWANA) — MESOZOIC (NEO-GONDWANA) — TERTIARY

Devonian, Carboniferous, Permian, Triassic, Cretaceous

B- MAP SHOWING RADIOACTIVE ANOMALIES AND LOCATION OF OTHER METALLIFEROUS OCCURRENCES

RADIOACTIVE ANOMALIES	•	COPPER, LEAD, ZINC	♦ Cu, Pb, Zn
IRON ORE	□ Fe	GOLD	✕ Au

FIGURE Nº2

GEOLOGICAL MAP OF URUGUAY IN RELATION TO RADIOACTIVE ANOMALIES AND OTHER METALLIFEROUS OCCURRENCES

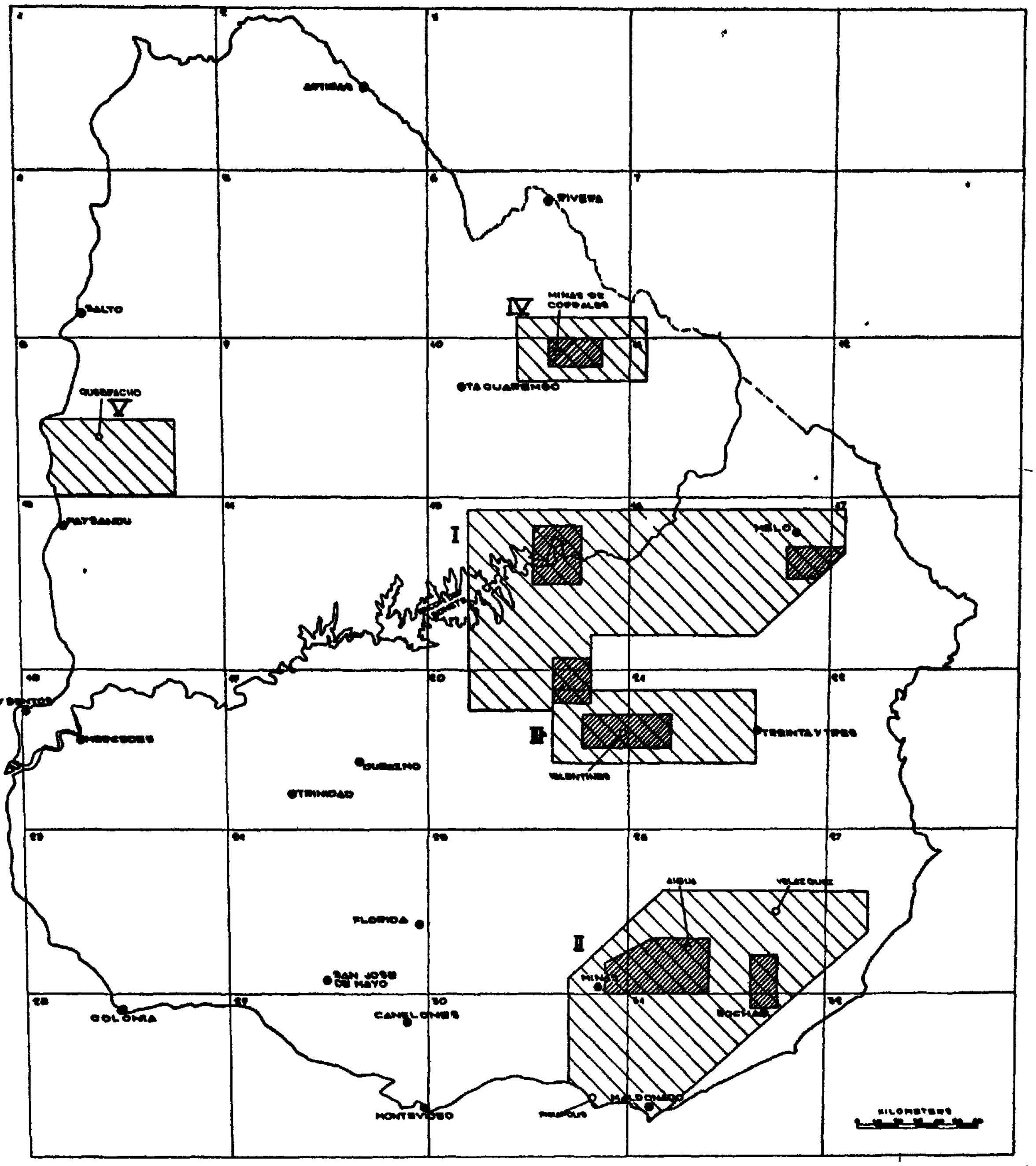


FIGURE Nº5

MAP OF URUGUAY SHOWING RECOMMENDED PROGRAMME FOR NUCLEAR RAW MATERIALS PROSPECTION

AREAS RECOMMENDED FOR DETAILED GEOLOGICAL SURVEYING AND RADIOMETRIC TRAVERSING

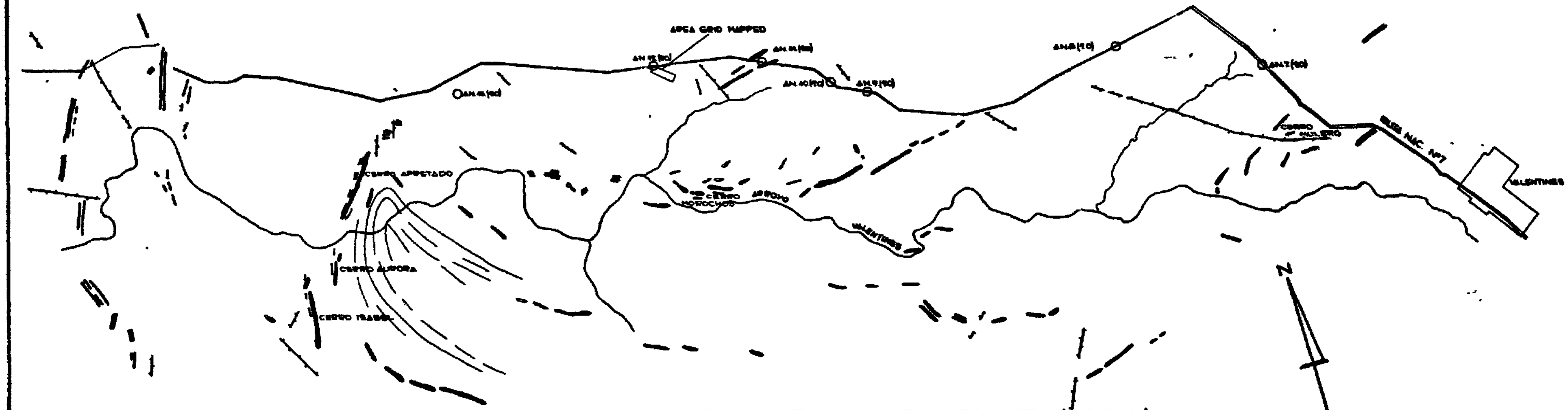
AREAS RECOMMENDED FOR FIRST PROGRAMME OF AERIAL SCINTILLOMETER SURVEYING

AREA I	RINCON DEL BONETE - MELO	12 000	km²
" " II	MINAS-ROCHA	8 500	km²
" " III	VALENTINES - TREINTA Y TRES	3 500	km²
" " IV	MINAS DE CORRALES	2 000	km²
" " V	QUEBRACHO	2 000	km²
	TOTAL	28 000	km²

AREAS RECOMMENDED FOR CONTINUATION OF CARBORNE SCINTILLOMETER SURVEY

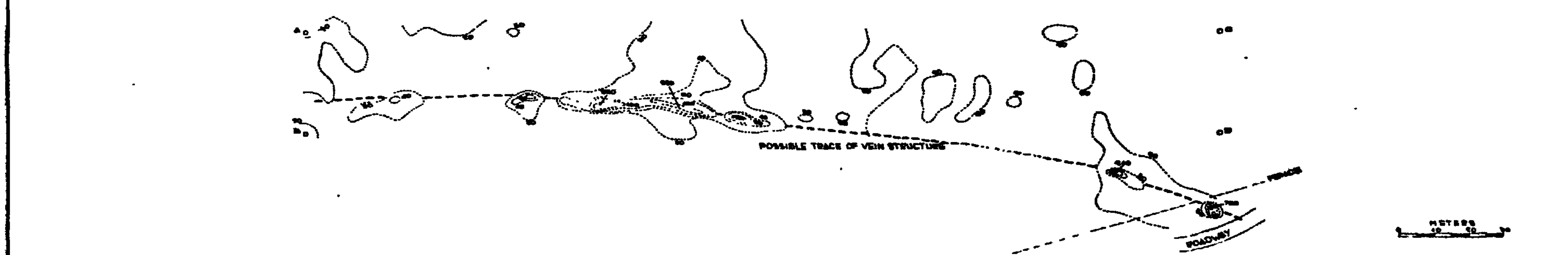
(AREAS NOT COVERED BY AERIAL SURVEY ONLY)

FIRST	PROGRAMME, SHEETS	15, 16, 20, 21, 25, 26
SECOND	" " " "	6, 7, 10, 11, 12, 17
THIRD	" " " "	8, 13, 18, 23



A- GEOLOGICAL STRUCTURAL MAP OF VALENTINES AREA (J. BOSSI)

IRON ORE ▬▬ RADIOACTIVE ANOMALIES o AN-(-)



B- ISORAD CONTOUR MAP OF ANOMALY 12.(20)

FIGURE Nº4

VALENTINES IRON ORE AREA SHOWING ANOMALIES DISCOVERED ON ENTRY ROAD AND ISORAD MAP OF ANOMALY 12.(20)

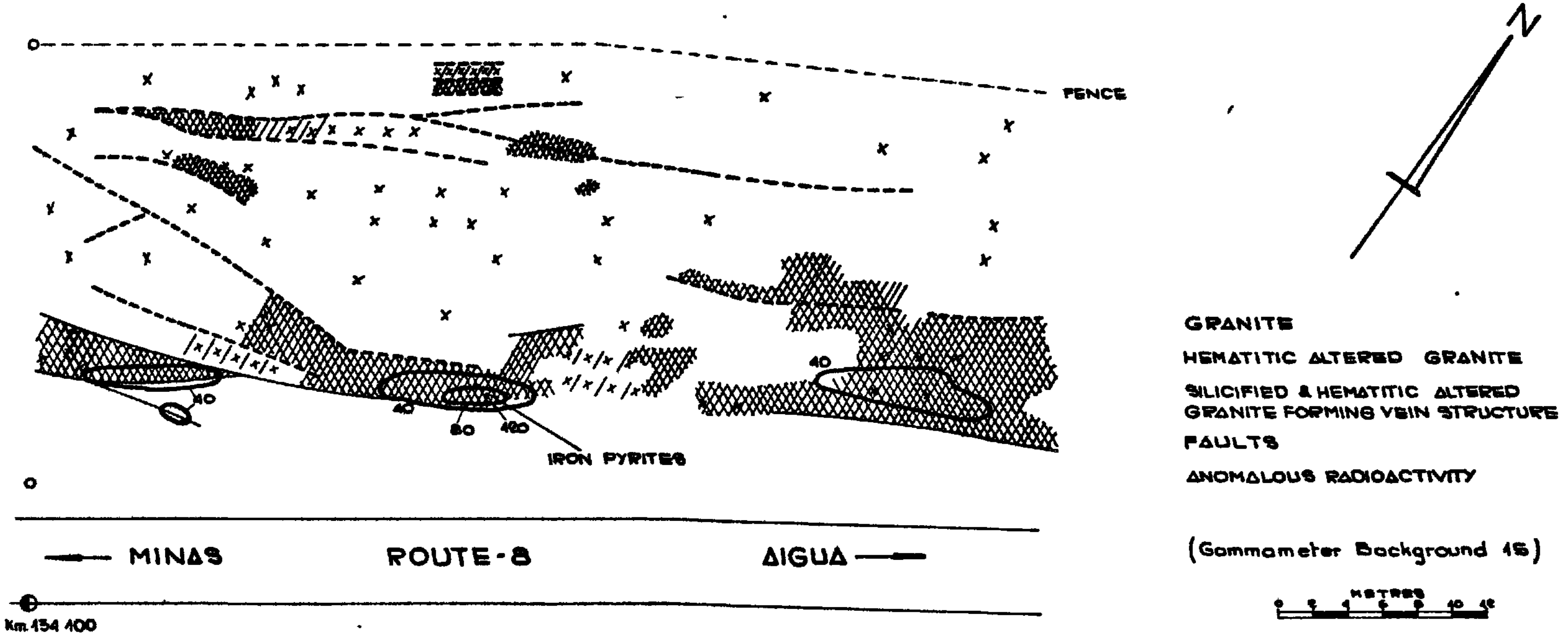


FIGURE N°5

GRID MAP OF ANOMALY 1.(25) AT km. 134 ROUTE-8

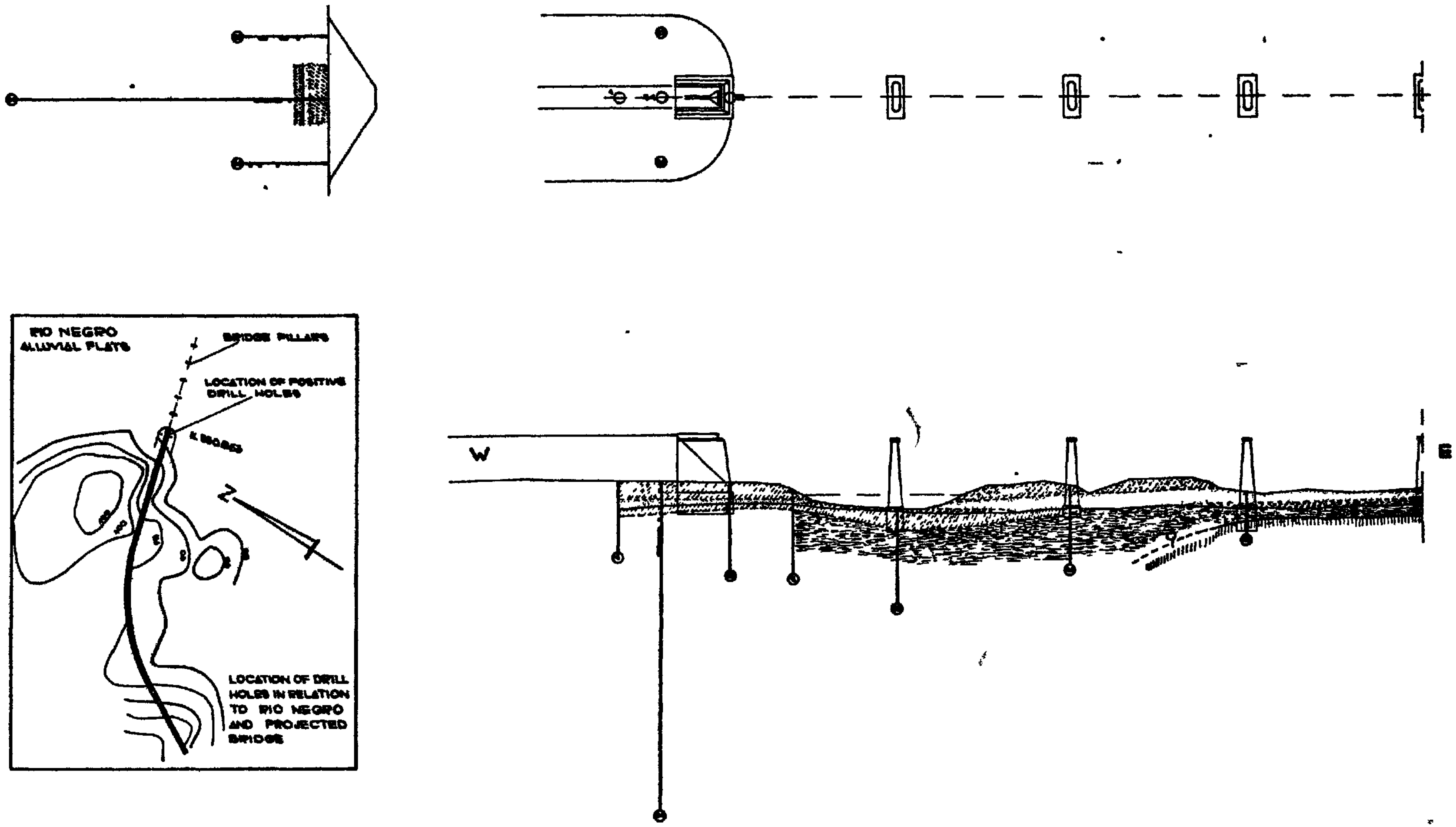


FIGURE N°6

PASO DE LAS PIEDRAS: BRIDGE OVER RIO NEGRO DPTO. OF DURAZNO (ANOMALY 4(45))

LOCATION OF DRILL HOLES SHOWING RADIOACTIVITY

EXISTING DRILL HOLES	O	ARENACEOUS ALLUVIALS		PEBBLES	
RADIOACTIVE ANOMALIES	|	SAND		SANDY SCHISTS	
ARGILLACEOUS ALLUVIALS		SAND WITH PEBBLES		ITARARE-SAN GREGORIO FORMATION	

FROM PLANS OF A.F.E. AND GEOLOGY AND DRILL HOLE ANOMALIES BY M.A. GRIMBERT

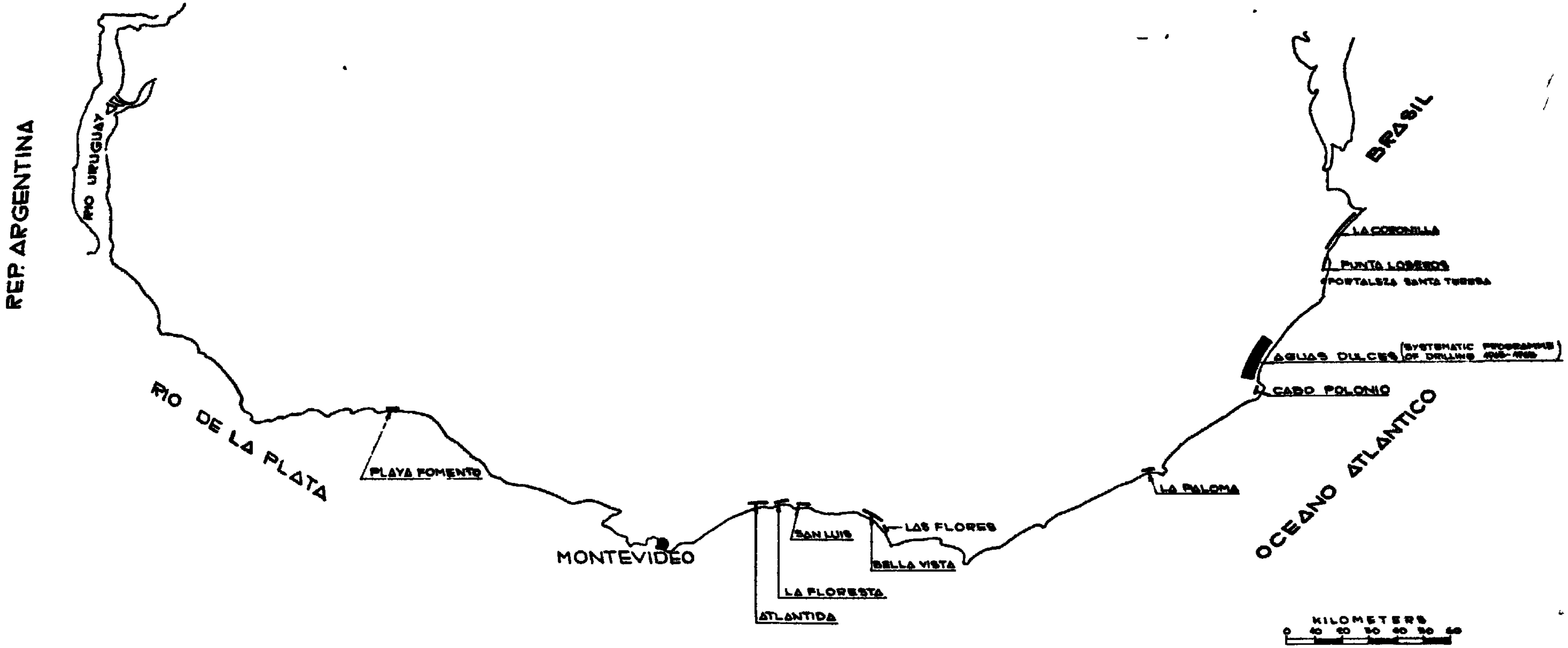


FIGURE N°7

HEAVY MINERAL COASTAL SANDS

LOCATION OF PRINCIPAL OCCURRENCES ON THE SOUTH COAST OF URUGUAY